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PULMONARY EMPHYSEMA ASSOCIATED WITH ARRESTED PULMONARY TUBERCULOSIS[1]

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THE purpose of my paper is to demonstrate how the x-rays can help in the diagnosis of emphysema, and to emphasize the importance of this study. I shall limit myself to emphysema in arrested tuberculosis, but I urge radiologists to help their clinical colleagues, as well as their patients, by trying to include or exclude emphysema whenever chest plates are read.

Emphysema, which is a constant sequela of arrested tuberculosis, is frequently associated with sinus infection and is a serious complication in most chronic lung lesions. This serious complication is frequently overlooked to-day. Severe cases of psychoneurosis, with attacks of bronchial asthma, generally have emphysema as a base.

Our text-books describe the barrel-shaped chest and cyanosis as the outstanding findings in emphysema. Cyanosis occurs either during acute attacks associated with asthma, or it is an end-result. The barrel-shaped chest is a late finding in tuberculous cases with emphysema.

Before 1890 clinicians paid great attention to this condition, but little has been added to the literature since 1900. The best references for a complete study of emphysema are in "Diseases of the Lung and Pleura," by Wilson Fox,[2] which was dedicated to Sir William Jenner. It is a joy to find that Jenner's article on emphysema, in Reynolds' System of Medicine, Volume I, published in 1871, is a classic. I have seen nothing which Jenner has not described. I am only trying to help detect upon the films in life what he found at autopsy.

The x-ray diagnosis of emphysema is greatly aided by the pathology. If you have dilated air cells and thickening of pulmonary arteries, you have a pathology which increases the contrast of thoracic density. The trunks are widely separated and, on good stereoscopic films, it is easy to make out the trachea, the right and left bronchus, the pulmonary arteries, and the trunks leading to the various lobes of the lungs.

It is not unusual for emphysema to be more marked in one lung than in the other; it is most striking to see emphysema more marked in an upper lobe than in another lobe of the same lung. This phenomenon can be detected easily by the greater separation of the trunks in the particular lobe involved. But let me repeat that good stereoscopic plates are a necessity and the radiologist must be familiar with the thoracic anatomy. If he is not able to locate the lobes by following the various trunks on

[1]Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

[2]Fox, Wilson: J. and A. Churchill, London, 1891.

good stereoscopic plates, he should not attempt to diagnose pulmonary emphysema.

When emphysema is severe, blebs are most often seen in the bases. These lesions have been well discussed by William Snow

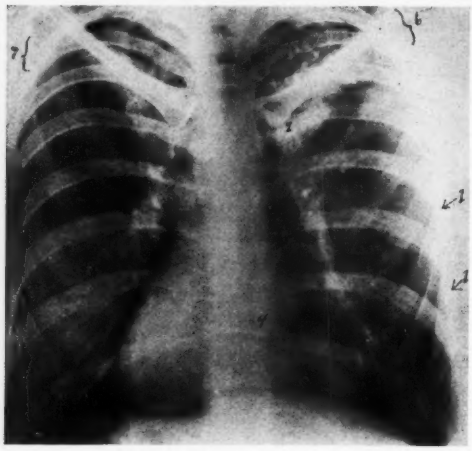

Fig. 1. Case 1. (1) Ribs wide and horizontal to spine; (2) right pulmonary artery dislocated up; (3) main stem bronchus inside pulmonary artery; (4) heart not seen to right of spine; (5) diaphragm, low and flattened; (6) old fibroid lesions in upper right; (7) marked emphysema, upper left; trunks in all lobes widely separated.

Miller,[3] after a study of a lung which I sent him, because I had made the diagnosis of emphysema from it during life. These large emphysematous areas, which are quite common, are sometimes mistaken for cavities. It was difficult for the radiologist to teach the clinician that bronchiectasis existed long before the three-layer sputum was found. It is going to be even more difficult to teach that there are many degrees of emphysema. We use the terms mild, moderate, and severe, but there is no sharp dividing line. More study is required. A better understanding of emphysema is of great clinical value.

Roentgenographic Technic. — Accurate stereoscopic films with good penetration, a lateral plate exactly exposed at right-angles to the anteroposterior diameter of the chest, and a carefully made fluoroscopic examination are necessary. To this I have added plates taken after the injection of iodized oil, because these will prove your other findings.

Let me repeat. Any study of chest plates requires ability to interpret accurately the anatomy shown on the plates. Many times penetration rather than contrast is all-important to bring out the anatomy. Contrast is doubled by the two plates. Further, the plates must stereoscope accurately.

Anatomy.—No two chests are alike and it takes much study to master the variations found in healthy chests. The bones, the trachea, the aorta, and the pulmonary arteries must be defined and their locations noted. The trunks leading to the upper lobes must be carefully studied. The middle lobe trunk, from the main stem bronchus on the right, and the lingual tip, from the bronchus of the upper left lobe, are very important; the bronchi to the upper third of each lower lobe, as they come off the right and left main stem bronchus, must also be located. When these landmarks are found, you have defined the lobation, and you are in a position to say whether or not there has been dislocation of the lobes and if the trunks to these various lobes are more or less widely separated than they should be. As I have said before, emphysema aids such a study.

Ribs.—The ribs are well separated. The angles of their lower borders with the spine are always more obtuse than in health, often being right-angles. The upper border may show the more acute angle of the two, as has been brought out by Pancoast and others. The barrel-shaped chest is a late finding and is not best detected by films; the fluoroscope shows it better, but simple inspection is best. Palpation easily discloses that the ribs move up and down, rather than expand. The costal cartilages are more or less calcified. This has been

[3]Miller, W. S.: Am. Jour. Roentgenol. and Rad. Ther., May, 1926, XV, 399-407.

Fig. 2. Case 1. Iodized oil. Cf. with Figure 1.

Fig. 3. Lateral exposure.

given as a cause of emphysema by Freund.[4] I believe that calcification of rib cartilage suggests only premature old age.

The *spine* is often bowed backward and the patient frequently has a bowed head, but, again, this is found only in long-standing cases.

Anterior and Posterior Dark Areas.—Others have shown frequently, on lateral exposures, that the anterior dark area extends down in front of the heart density, separating it from the sternum. This is true except in cases in which the pericardium is attached to the anterior chest wall. In such a case, the posterior dark area is usually large. These points are well seen by the fluoroscope, but the films make the record.

Diaphragm.—The diaphragm is always low and is restricted in its movements, a fact which is best detected by the fluoroscope. It must be remembered that the diaphragm in healthy individuals moves up and down much more than one would expect. It is easy to believe that the diaphragm is moving normally when it really is greatly restricted. Further, the principle of the orthodiagraph should be used, because movement is easily magnified by improper fluoroscopic examination.

Dislocation of Thoracic Viscera.—It has been striking to note to what extent the thoracic viscera may be dislocated by pleurisy and the contractile scar tissue of tuberculosis. The good lung expands to fill the thoracic cavity, the anatomic landmarks previously described are moved, and the trunk markings are abnormally separated. In this way we have our most characteristic x-ray presentation of pulmonary emphysema. I have seen the left pulmonary artery dislocated almost to the top of the aorta.

Emphysematous blebs are a late manifestation and indicate severe emphysema. Asthma, cyanosis, and the barrel-shaped chest are frequently not present. Blebs, which are seen best at the inferior margins, may occur in an upper lobe or the upper third of a lower lobe, in which case they suggest cavity.

Injection of Iodized Oil.—For several years I have noted that, in certain cases injected with iodized oil, the oil did not fill the air cells, and, therefore, did not present

[4]Freund (Wurzb. Verhandl., 1859, IX) thought that the first stage was an elongation of the cartilages of the upper ribs, by which they were forced upward and outward, and the sternum forward and upward. It is now generally believed, as stated by Jenner, that Freund mistook the effect for the cause.

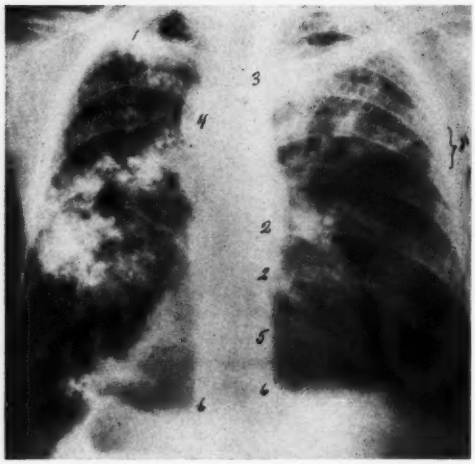

Fig. 4. Case 2. (1) Old fibroid lesions with emphysema; (2) ribs wide apart and at right-angles to spine; (3) clavicles, right lower than left; (4) aorta suggests arteriosclerosis; (5) heart not seen to right of spine; (6) diaphragm very low; (7) blebs at right base; (8) marked emphysema below fibroid lesion in right upper; (9) marked emphysema below fibroid lesion in left base; (10) probable blebs above left diaphragm.

Fig. 5. Case 2. Iodized oil. (1) Left bronchus dislocated upward; (2) main stem bronchus dislocated upward and outward; (3) trunks to left lower lobe dislocated upward; (4) blebs at left base; (5) trunks on right widely separated; emphysematous blebs do not fill; no density in the lungs resembling caseous bronchopneumonia.

the picture of a bronchopneumonia. Instead, the oil left a beautiful picture of the bronchial tubes. At first, I thought this was due to the quantity of oil used, and then I thought it might be due to the uneven temperature of the oil injected. Neither of these was correct, and it finally dawned upon me that these cases of uninjected air cells were all cases of emphysema. Such cases were sometimes associated with asthma and bronchitis, sometimes with bronchiectasis, and at other times with tuberculosis. The important point is that the air cells do not fill with the oil, and we have never had an emphysematous bleb that filled. This is similar to a cavity—cavities seldom fill with the oil. When Bloch published his article on viscosity,[5] I determined to compare a very cold (18° C.) and a warm injection (38° C.). There is no difference on the films.

The importance of the study of emphysema cannot be over-estimated. Many patients are unable to carry on, even after their tuberculous lesions have become fully arrested. Many patients are returned to the sanatorium after discharge, because they have severe cough and expectoration and the chest is full of râles. At times, such patients are so sick that they cannot recline, but must be propped up in bed. An x-ray plate shows no new pulmonary lesions since the last examination. The clinician believes that there has been an extension of a tuberculous lesion which the x-ray does not show. After a few weeks in bed the patient rests easily, the cough subsides, and the râles cannot be heard.

Such were the cases which first attracted my attention many years ago. A more careful study of the subject reveals that some degree of emphysema is associated with every case of arrested tuberculosis. When such a case is returned to his home, the physician has not fulfilled his duty unless he has carefully observed the exercise of that patient, to determine how many hours he should be up, without rest in bed. Few cases of arrested tuberculosis should be up more than twelve hours: some cannot be

[5]Bloch, R. G.: Am. Jour. Roentgenol. and Rad. Ther., June, 1932, XXVII, 847-852.

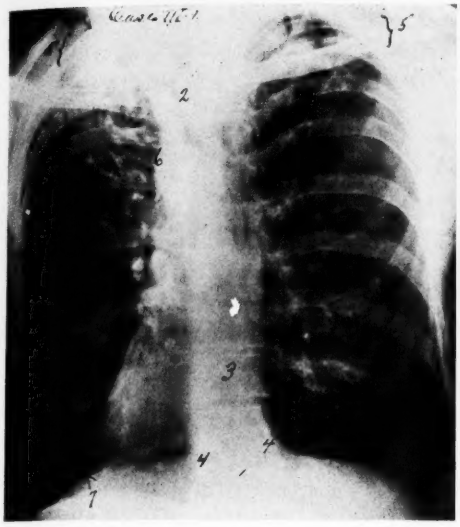

Fig. 6. Case 3. Ribs very wide throughout. (1) Ribs contracted over left upper; (2) trachea drawn to the left; (3) heart not seen to right of spine; (4) diaphragm very flat, especially left dome; (5) old fibroid lesions, both uppers, but most marked on left; (6) aorta drawn to the left; (7) emphysematous blebs at left base, less evident on right.

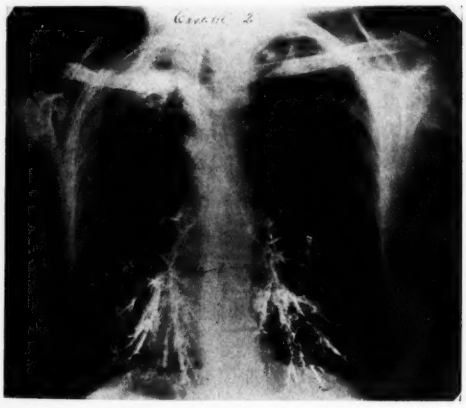

Fig. 7. Case 3. Iodized oil (38° C.). (1) Trunks dropped; stereoscopic films show them to be widely separated in antero-posterior diameter. Slightly more mottling of caseous broncho-pneumonia than in Figure 6.

up safely more than three hours, followed by at least two in bed. The hours up must be prescribed for each individual case of arrested tuberculosis, since each presents a different problem. While the heart, kidneys, and other organs play a part, emphysema is the greatest and most common handicap.

Fig. 8. Case 3. Iodized oil (18° C.). Injection of the lower part of the upper right lobe due to position and not to cold oil; mottling is about the same; blebs are seen at both bases; very little difference between the hot and cold oil.

It is to be remembered that such patients can do much more in the warm months than in the cold months. Infections (colds) in the upper or lower air passages greatly reduce the lung capacity, and this should be given serious consideration.

Less severe cases of emphysema associated with arrested tuberculosis present many symptoms. Erroneous diagnoses have been given, such as tuberculosis reactivated, psychoneurosis, nervous exhaustion, heart lesions of many varieties, chronic bronchitis, bronchiectasis. I have not tabulated all of them and cannot now remember the whole list.

The important point is, when you examine a patient who is an arrested case of tuberculosis—no matter how long arrested, no matter how slight the lesion—consider and determine the extent to which pulmonary emphysema is causing the trouble. The x-rays are of great value in determining this. Remember that rest is the only treatment and, the later you make the diagnosis, the more rest is required.

RECOMMENDATIONS OF THE THIRD INTERNATIONAL CONGRESS OF RADIOLOGY RELATING TO PROTECTION FROM X-RAYS AND RADIUM

By LAURISTON S. TAYLOR, Bureau of Standards, WASHINGTON, D. C.

Abstract.—The 1928 x-ray and radium protection proposals,[1] as revised and adopted by the Third International Congress of Radiology, Paris, 1931, are given in their final form.

I. INTRODUCTION

At the Second International Congress of Radiology, at Stockholm, in 1928, preliminary recommendations on x-ray, radium, and high voltage protection were adopted. At the same time a committee was appointed, for the further consideration of these proposals, which was to meet and render a report to the Third International Congress of Radiology, at Paris, in 1931. This committee consisted of the following representatives of their respective countries:

G. Grossman, Germany.
R. Ledoux-Lebard, France.
R. Sievert, Sweden.
I. Solomon, France.
L. S. Taylor, United States.
E. Pugno Vanoni, Italy.
G. W. C. Kaye, Great Britain } *Honorary*
F. Melville, Great Britain } *Secretaries*

At its meeting during the 1931 congress, certain revisions were made in the 1928 proposals. These changes are incorporated in the complete recommendations given below. At the same time provision was made for the formation of a subcommittee to make extensive revision of the parts on radium protection before the 1934 congress.

The recommendations as given below were adopted by unanimous consent by the members of the Third International Congress of Radiology.

II. RECOMMENDATIONS AS ADOPTED

1. The dangers of over-exposure to x-rays and radium can be avoided by the provision of adequate protection and suitable working conditions. It is the duty of those in charge of x-ray and radium departments to insure such conditions for their personnel. The known effects to be guarded against are:

(*a*) Injuries to the superficial tissues.
(*b*) Derangements of internal organs and changes in the blood.

1. *Working Hours, etc.*—2. The following working hours, etc., are recommended for whole-time x-ray and radium workers:

(*a*) Not more than seven working hours a day.
(*b*) Not more than five working days a week. The off-days to be spent as much as possible out of doors.
(*c*) Not less than 4 weeks' holiday (vacation) a year, preferably consecutively.
(*d*) Whole-time workers in hospital x-ray and radium departments should not be called upon for other hospital service.
(*e*) X-ray workers and particularly radium workers should be systematically submitted, both on entry and subsequently at least twice a year, to expert medical, general, and blood examinations. These examinations will determine the acceptance, refusal, limitation, or termination of such occupation.

2. *General X-ray Recommendations.*—3. X-ray departments should not be situated below ground-floor level.

4. All rooms, including dark rooms,

[1] B. S. Circular No. 374, 1929.

should be provided with windows affording good natural lighting and ready facilities for admitting sunshine and fresh air whenever possible.

5. All rooms should be provided with adequate exhaust ventilation capable of renewing the air of the room not less than ten times an hour. Air inlets and outlets should be arranged to afford crosswise ventilation of the room.

6. All rooms should preferably be decorated in light colors.

7. A working temperature of about 18° C. (65° F.) is desirable in x-ray rooms.

8. X-ray rooms should be large enough to permit a convenient lay-out of the equipment. A minimum floor area of 250 square feet (25 square meters) is recommended for x-ray rooms and 100 square feet (10 square meters) for dark rooms. Ceilings should be not less than 11 feet (3.5 meters) high.

9. Wherever practicable the x-ray generating apparatus should be placed in a separate room from the x-ray tube.

3. *X-ray Protective Recommendations.*

10. An x-ray operator should on no account expose himself unnecessarily to a direct beam of x-rays.

11. An operator should place himself as remote as practicable from the x-ray tube.

12. The x-ray tube should be surrounded as completely as possible with protective material of adequate lead equivalent.

13. The following lead equivalents are recommended under average conditions:

X-rays Generated by Peak Voltages Not Exceeding	Minimum Equivalent Thickness of Lead
(K.V.)	(mm.)
75	1
100	1.5
125	2
150	2.5
175	3
200	4
250	6
300	9
350	12
400	15

14. In the case of diagnostic work, the operator should be afforded protection from scattered rays by a screen of a lead equivalent not less than 1 millimeter.

15. In the case of x-ray treatment the operator is best stationed completely outside the x-ray room behind a protective wall of a lead equivalent not less than 2 millimeters. This figure should be correspondingly increased if the protective value of the x-ray tube enclosure falls short of the values given in Paragraph 13. In such event the remaining walls, floor, and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending on the circumstances.

16. Screening examinations should be conducted as rapidly as possible, with minimum intensities and apertures. Palpation with the hand should be reduced to the minimum.

17. The lead glass of fluorescent screens should have the protective values recommended in Paragraph 13.

18. In the case of screening stands the fluorescent screen should, if necessary, be provided with a protective "surround" so that adequate protection against direct radiation is afforded for all positions of the screen and diaphragm.

19. Screening stands and couches should provide adequate arrangements for protecting the operator against scattered radiation from the patient.

20. Inspection windows in screens and walls should have protective lead values equivalent to that of the surrounding screen or wall.

21. Efficient safeguards should be adopted to avoid the omission of a metal filter in x-ray treatment.

22. Protective gloves, which should be suitably lined with fabric or other material, should have a protective value not less than ⅓ mm. lead throughout both back and front (including fingers and wrist). Protective

aprons should have a minimum lead value of ½ millimeter.

4. *Electrical Precautions in X-ray Rooms.*—23. The floor covering of the x-ray room should be of insulating material, such as wood, rubber, or linoleum.

24. The overhead conductors should be not less than 9 feet (3 meters) from the floor. They should consist of stout metal tubing or other coronaless type of conductor. The associated connecting leads should be of coronaless wire kept taut by suitable rheophores.

25. Wherever possible earthed guards or earthed sheaths should be provided to shield the more adjacent parts of the high tension system. The use of x-ray equipment having the high tension circuit completely enclosed in earthed conductors is specially recommended. Unless there are reasons to the contrary, metal parts of the apparatus and room should be efficiently earthed.

26. The use of quick-acting double-pole circuit breakers is recommended. Overpowered fuses should not be used. If more than one apparatus is operated from a common generator, suitable overhead multi-way switches should be provided.

27. Some suitable form of kilovoltmeter should be provided to afford a measure of the voltage operating the x-ray tube.

28. Special electrical precautions should be taken in rooms where anesthetics are used in conjunction with x-rays.

5. *Film-storage Precautions.*—29. The use of non-flammable x-ray films should be encouraged. In the case of flammable films, suitable precautions should be taken as regards their use and storage. Large stocks should be kept in isolated stores, preferably in a separate building or on the roof.

6. *Radium Protective Recommendations. (A) Radium Salts.*—30. Protection for radium workers is required from the effects of: *(a)* beta rays upon the hands, and *(b)* gamma rays upon the internal organs, vascular, and reproductive systems.

31. In order to protect the hands from beta rays, reliance should be placed, in the first place, on distance. The radium should be manipulated with long-handled forceps, and should be carried from place to place in long-handled boxes, lined on all sides with at least 1 cm. of lead. All manipulations should be carried out as rapidly as possible.

32. Radium, when not in use, should be stored in a safe as distant as possible from the personnel. It is recommended that radium tubes or applicators be inserted into separate lead blocks in the safe, giving a thickness of protective wall amounting to the values given in the following table:

Maximum Quantity of Radium Element	Thickness of Lead
(gm.)	(cm.)
.2	8.5
.5	10
1.0	11.5
2.0	13
5.0	15
10.0	17

33. A separate room should be provided for the "make-up" of screened tubes and applicators, and this room should be occupied only during such work.

34. In order to protect the body from the penetrating gamma rays during handling of the radium, a screen of not less than 2.5 cm. of lead should be used, and proximity to the radium should occur only during actual work for as short a time as possible.

35. The measurement room should be a separate room and it should preferably contain the radium only during its actual measurement.

36. Nurses and attendants should not remain in the same room as patients undergoing radium treatment with quantities exceeding one-half gram.

37. All unskilled work or work which

can be learned in a short period of time should preferably be carried out by temporary workers, who should be engaged on such work for periods not exceeding six months. This applies especially to nurses and those engaged in "making-up" applicators.

38. Discretion should be exercised in transmitting radium salts by post. In the case of small quantities it is recommended that the container should be lined throughout with lead not less than 3 mm. thick. It is more satisfactory to transport large quantities by hand in a suitably designed carrying case.

(B) Emanation.—39. In the manipulation of emanation, protection against the beta and gamma rays has likewise to be provided.

40. The handling of emanation should be carried out, as far as possible, during its relatively inactive state.

41. The escape of emanation should be very carefully guarded against, and the room in which it is prepared should be provided with an exhaust fan.

42. Where emanation is likely to come in direct contact with the fingers, thin rubber gloves should be worn to avoid contamination of the hands with active deposit. Otherwise, the protective measure recommended for radium salts should be carried out.

43. The pumping room should preferably be contained in a separate building. The room should be provided with a connecting tube from the special room in which the radium is stored in solution. The radium in solution should be heavily screened to protect persons working in adjacent rooms. This is preferably done by placing the radium in solution in a lead-lined box, the thickness of lead recommended being according to the table in Paragraph 32.

III. DISCUSSION

The proposals do not specify the use of sheet lead, but state that a certain "lead equivalent" be used. Sheet lead is, however, the safest and most permanent protection, and should be used whenever possible.[2] If protective plasters are used, great care must be taken in their preparation and application in order to insure a uniform protective value. Papers by Hunt[3, 4] discuss the properties and use of such materials.

In most x-ray departments the lighting is inadequate and the ventilation poor. These are two factors which are very commonly overlooked in the design of x-ray departments and consequently particular attention should be given to Paragraphs 4 and 5.

There is frequently also a lack of sufficient auxiliary protective aprons on screening stands and couches, thus exposing the operator to the very soft radiation scattered from the patient's body. This is one of the most common sources of danger to the doctor.

Since the Second International Congress of Radiology in 1928, the Advisory Committee on X-ray and Radium Protection in the United States has drawn up a very complete set of x-ray and high tension protection recommendations.[5] It is believed that these recommendations contain all the information necessary to provide adequate protection under all conditions.

While with the advent of new self-protected x-ray tubes, and new apparatus, such as high tension cables and oil-immersed equipment, many of the problems in protection are simplified, the older type of equipment will undoubtedly be used for some time, and, therefore, proper attention should be given to all new installations as well as existing ones.

In order to continue the work in protection, the Congress has retained the Protection Committee which will report any

[2] L. S. Taylor, X-ray Protection. Am. Jour. Roentgenol. and Rad. Ther., 1929, XXII, 45.
[3] F. L. Hunt and M. Temin, RADIOLOGY, February, 1927.
[4] F. L. Hunt, Am. Jour. Roentgenol. and Rad. Ther., 1925, XIV, 524.
[5] Bureau of Standards Handbook No. 15, 1931. RADIOLOGY, 1931, XVII, 542. Am. Jour. Roentgenol. and Rad. Ther., 1931, XXVI, 436.

further progress at the Fourth International Congress of Radiology, at Zürich, in 1934. In this country we have an Advisory Committee which will recommend any changes or additions arising from experience and advance in the United States. To this Committee should be referred any questions or suggestions regarding x-ray protection and, if no settlement can be reached, they will be taken up by the International Committee. Communications pertaining to the code should be transmited through the author, who is the American representative on the International Committee.

SHALL WE RECORD AND REPORT ALL X-RAY DOSAGE IN ROENTGENS?[1]

By R. R. NEWELL, M.D., San Francisco
Stanford University School of Medicine

THIS is not a report of physical measurement, nor a record of clinical observations. What I have to present is a proposition for discussion.

It was three and a half years ago that we were given a precisely defined and internationally accepted unit of roentgen dosage. It is true that the realization of the official unit, the roentgen, and its distribution to clinical roentgen therapists have proved difficult. Clinical roentgenometers do not always agree perfectly with each other, which makes one feel uncertain as to the correctness and permanence of their calibration. One feels like sending his instrument to our U. S. Bureau of Standards for calibration. Another possibility appears in Rajewski's (1) radium standard for small ionization chambers, so arranged as to be little susceptible to small errors in the geometrical arrangement of the test. With this, one could carry the standardization (or, rather, the check on original calibration) to the instrument instead of sending the instrument to Washington. Taylor has told us that he carried a primary standard around Europe and found the national institutes in good agreement. With their service available to users of clinical roentgenometers, I think practical roentgenometry is reaching a satisfactory state of dependability.

The cost of a good roentgenometer, with small chamber calibrated in r, is not too great for us to afford. Expensive ones may be had with an integrating arrangement to keep account of the total amount, but I cannot see the necessity for this as long as we have clocks.

Gamma radiation has always been outside the calibrated range of our ionometers, the factor for wave length being unknown for a small chamber of any construction. Failla and Henshaw (2) have recently given us a good evaluation of the r per minute intensity of a gamma-ray beam (36 r per minute per gram of radium element at 1 cm. distance). It is interesting to note that a graphite chamber could be recalibrated for gamma rays and prove dependable, but if they had used its constant as calibrated for hard x-rays, it would have indicated nearly four times the radiation intensity actually there.

These gamma-ray measurements concern the amount in a beam of radiation. Measurement of a roentgen ray can be done in the beam with good precision, within a few per cent. However, when radiation enters the body it is augmented by scattering, or,

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

rather, its absorption is so augmented, for some elements of the tissue are irradiated twice by the same beam, once going in and once scattered back, and the tissue exacts its toll of energy absorbed at each passage. It has become a common practice to measure roentgen dosage at the patient's skin, which includes the back-scattering. The argument for this method is that this is the dosage which is really effective in the patient's tissues (skin, usually), and that it is easier to measure the total than to estimate it from the beam. The augmentation due to scattering depends on the wave length, the distance from the tube, the size of area, and the size, shape, and composition of the part irradiated. However, with the same tissue dose at the surface, the tissue-response, especially the ultimate recovery, may depend on the same things, namely, wave length, distance, area, and part (and also on some others, as rate of application, age of the patient, idiosyncrasy), so we have to specify all these things anyhow, for a complete record.

Now I think the measurement of dosage intensity on the skin is much less dependable than measurement of roentgens in the beam. Even in the simple case of the water-phantom it appears that different investigators fail signally to agree. Gunsett (3) has shown how error may be produced by change of ionization-chamber constant with change of wave length,[2] because the scattered rays are of longer wave length than the incident beam. Also, we must note that the intensity at the center of a large skin area is greater than at the edges, even though the beam is uniform.

The whole problem of scattering, with its effect on distribution of energy and alteration of wave length, needs more study and needs to be carried into the gamma-ray range. Also, much more work needs to be done in regard to relation of biologic effect to wave length. Nevertheless, we ought to use what knowledge we have and measure or calculate as best we can the tissue dose in every case we treat. This can be done for radium as well as x-ray and when both agents are used on the same part, the tissue doses can be added to give a notion of the total effect. Tissue dosage, not being uniform, would have to be estimated for critical points, so that a maximum safe skin dose be not exceeded and a minimum effective tumor dose be attained, if possible, throughout.

To sum up, for a precise record of what treatment was given, we should make the record in roentgens. To the end that treatments may be wisely planned and their effects better understood, we ought also to map out the distribution of radiation effect (tissue dose) in the patient. I shall make a separate heading for each of these two complementary ideas.

ROENTGENS

A roentgen beam is a stream of radiation. Its intensity is the energy it carries per square centimeter. To measure this energy one must absorb the beam completely. If we absorb only part of it, as in a standard ionization chamber, it will appear more or less intense, according to its absorbability. The international unit, then, is a measure of the product of quantity and absorbability. One roentgen is that amount of x-ray which will produce a unit effect in air. It is not, strictly speaking, a unit of dose, for dose concerns effect, not on air but on flesh. The latter may parallel the former, but it is not identical with it. (I am speaking of immediate effect, *i.e.*, ionization.)

A narrow, uniform beam of x-ray is used to calibrate a thimble chamber in international r. This step is done at the factory or

[2]For a 400 square centimeter area the total reading of a graphite chamber was 138 per cent compared to the incident beam, whereas Dauvillier's xenon chamber gave a total reading 225 per cent of the incident beam.

at the Bureau of Standards. The thimble chamber is set under the tube, port, and filter at the point where the patient will be placed for treatment. Here it measures in air the amount of x-ray per minute that will be applied to the patient when he takes its place. This is, or can be, precise and measures r by the effect in air, as internationally defined.

DOSE

What we are interested in is the tissue dose and I think we would better always call it by its full name—"tissue dose."

A given amount of x-ray (roentgens) of a given quality applied at a given anode-skin distance to a given area on a given part of the body will produce a given tissue dose. If it is a solid part of the body, we can calculate from water-phantom data; if it is a heterogeneous part (like the chest), we can make shift by using our same thimble chamber, but we must not delude ourselves into thinking we are measuring the dose—we are measuring only the amount of x-ray in the neighborhood, from which we can judge more or less accurately the tissue dose.

If we are to keep thinking straight, I believe it is important that we reserve the word "roentgen" for amount of x-ray measured in air (in the beam), and so we must find a differently named unit for tissue dose. Dauvillier (4) suggests "ergs per cubic centimeter." The Memorial Hospital clings to "erythema dose." The former seems too precise for a thing we know so uncertainly (in absolute units); the latter seems a bit lacking in precision. I think it would be well to give to the Standardization Committee of this Society the task of defining and naming a unit of tissue dose that may be satisfactory.

CONCLUSIONS

The roentgen is not a unit of tissue dose; it is a unit of amount of roentgen ray producing a defined effect in air. It should be measured in the beam.

A proper record of a roentgen treatment will embody the following data:

r applied (in the beam);
quality (half value layer in copper; or, for softer ray, in aluminum);
area and part treated;
anode-skin distance;
rate of application (or total duration of exposure);
estimation of tissue dose for skin and depth.

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DISCUSSION

Dr. George E. Pfahler (Philadelphia): I have been deeply interested in the subject of dosage from the time measurement was by means of the Sabouraud-Noiré pastilles up to photographic strip paper. I prepared an article on this subject many years ago, and then I was one of the first to get the iontoquantimeter, of which I have had four.

I must admit that, while the whole idea appeals to me tremendously, I do not feel that these iontoquantimeters, as prepared and distributed to us, are quite what they ought to be for practical radiologists, such as we are. I have at the present time three of the very best iontoquantimeters. One of them is out of commission because of the insulation, but the other two are supposedly in first-class working order. These two were measured within two weeks against a third, which was measured at the Bureau of Standards. All three were supposedly measured in r units, one of them by the German Bureau of Standards, the other two having been checked against instruments measured at the Bureau of Standards in this country; yet these three instruments, put in the same field of irradiation, give markedly different readings.

That does not condemn the instrument. It just means that we have not quite brought the iontoquantimeter into the practical field in which we, as untrained physicists, must work with it. The idea is correct, and surely we are approaching more and more to exact dosage, which must be our aim. I have learned in my own laboratory, for instance, just about what I can do to cause a certain biologic effect, but it is still difficult for me to carry over to the rest of you the idea of just what I am doing. That is the object of the r unit. Whether we measure a dose in Philadelphia, or St. Louis, or Paris, or Stockholm, that r unit should be the same. When we give 650 or 700 r units, which would perhaps be our interpretation of the average erythema dose, that should mean just the same in each of these places, and until it does do that, we have not quite accomplished our object. We will succeed. It is only a matter of the physicists checking over these instruments and telling us what errors we are making, or correcting the errors in the instruments themselves.

DR. G. FAILLA (New York City): Dr. Newell's paper is very important and timely because it focuses our attention on a subject about which considerable confusion exists. This confusion was brought about by introducing a unit of x-radiation before it had been properly worked out, especially in regard to its limitations, and before the profession was technically equipped to use it. The situation, however, is much better to-day than it was a year or so ago.

We know, from Dr. Taylor's report to this Society, that there is close agreement among the independent determinations of the roentgen, or r unit, made in the national laboratories of England, Germany, France, and the United States. Accordingly, we are sure now that instruments can be calibrated properly in these countries. But the radiologist is interested primarily in the calibration of his own instrument. Better, he is interested in the permanency of this calibration after the instrument leaves the Bureau of Standards. I have heard of several instances in which a radiologist who placed two or more instruments in the same beam of x-rays has obtained a different value of the intensity with each instrument. The discrepancy may be 25 per cent, or even 50 per cent. Naturally, this is disconcerting to the radiologist and he is apt to lose faith. In the near future, this trouble will be eliminated entirely, either by the introduction of new instruments, which maintain their calibrations, or by the provision of a radio-active standard with each instrument. The radiologist can rely on the physicist to solve this problem.

The radiologist must solve for himself the problem of the proper use of the unit. He must first familiarize himself with its significance and its limitations. The roentgen, or r unit, represents a certain *quantity* of x-rays, just as the ounce represents a certain quantity of a drug. A treatment specified by stating only the number of roentgens administered is meaningless, because the effect produced depends also on other factors. A dose of radiation should be specified in such a way that any experienced radiologist can form a definite idea of the biologic effect to be expected. No one can predict what biologic effect will be produced in a patient by the administration of 1,000 r without knowing also the type of radiation used, its distribution within the body, the length of time during which it was administered, etc. It is important, therefore, to have in mind at all times all the factors which influence the biologic effects of radiation.

In radiotherapy, in which we always deal with complicated systems, this is not a simple matter. In general, we have one tissue (tumor) which we wish to destroy, and one or more tissues which we must not damage permanently. A knowledge of the distribution of radiation within the tissues which must necessarily be irradiated is, therefore, absolutely essential, but it is by no means sufficient.

For the purpose of the present discussion, I shall dwell on only one of the many difficulties which Dr. Newell has in mind. The biologic effectiveness of a certain quantity of radiation, expressed in r, varies with the quality of the radiation. Thus the erythema dose for unfiltered low voltage x-rays is about 300 r, for highly filtered 200 K.V. x-rays, it is

600 r, and, for gamma rays, Dr. Glasser estimates it to be 2,000 r. When hard rays of a definite quality, determined in air, strike the tissues, the quality is changed considerably, the change being more marked at greater tissue depths. This brings about a change in biologic effectiveness, and, therefore, the same number of r at the surface of the body, and at a considerable depth below, have not the same biologic potentiality, so to speak. The situation here is somewhat analogous to the simultaneous irradiation of the skin with a combination of x-rays and gamma rays. Suppose that the x-ray tube target contains 10 gm. of radium. The intensity of the combined beam of gamma and x-rays can be measured in r per minute by means of an ionization instrument, but we would not be able to determine from this the length of the exposure required to produce an erythema.

It is with the idea of circumventing these difficulties that Dr. Newell suggests that the use of the unit be limited to the specification of the intensity of the x-ray beam in air without the disturbing influence of the patient's body. Then he suggests that some other unit be adopted for the specification of tissue dosage. I am inclined to agree with Dr. Newell in his first proposal, at least to the extent that the intensity of the x-ray beam measured in air should always be stated, irrespective of any other measurements which may be made during a treatment. But the introduction of an additional unit at this time is highly undesirable. In the first place, with our present knowledge, we cannot devise a unit for tissue dosage which is satisfactory, especially if the same unit is to be used for both x-ray and radium treatments. Any unit we can think of involves the same fundamental difficulties as the r unit. This applies both to physical and biologic units.

Experiments are now in progress which will throw considerable light on this problem. It is desirable, therefore, to await the outcome of these before we consider the adoption of a new unit, which may have to be discarded later. If, with some well understood limitations, the r can be used in practice for measurements of both radiation emission (intensity at a certain point in air) and tissue dose, it will be preferable to the use of two separate units. While awaiting a practical solution of this problem, the radiologist should always determine the x-ray emission of his apparatus in terms of the r unit. This will enable him to duplicate treatments with the least uncertainty, and will make his technic intelligible to others. After all, the r was introduced in order to serve these two purposes, and it does that very well. Later, if it is found that it can be used for other purposes, so much the better.

DR. NEWELL (closing): I have had a great deal of conversation about this matter since I came to the meeting. They tell of Cecil Rhodes that one of his friends accused him of changing his mind on some subject. He admitted the charge, and said, "Yes, I changed my mind as quickly as I could because I found out that I was wrong." I have written the paper over three times since I left San Francisco—that is only a measure of my belief that it needs more argument and discussion.

ROENTGENOLOGIC EXAMINATION OF THE DIGESTIVE TRACTS OF INFANTS AND CHILDREN[1]

By LEON T. LEWALD, M.D., Professor of Roentgenology, New York University and Bellevue Hospital Medical College; Attending Roentgenologist, Willard Parker Hospital, NEW YORK

IN a very young infant, or an unruly older child, it may be necessary to administer the opaque meal through a catheter or stomach tube. In order to facilitate this procedure, as the mixture is usually too thick to flow quickly through a tube attached to a funnel, the meal may be introduced through a syringe attached to the end of the stomach tube. Infants able to nurse from a bottle may have the opaque meal given in this way, using the ordinary feeding formula, and adding to it one part of barium sulphate to about eight parts of food. The quantity of food administered is about that of an average feeding for the age of the child. In children over two years of age, a mixed feeding may be given, such as a cup of cocoa and a dish of cereal to which has been added one part of barium sulphate to eight parts of the substances used. Some children can be tempted to take the barium in ice cream. Occasionally, an older child will take the ordinary barium sulphate cream used in the examination of adults.

Whatever food is given, it is advisable to observe fluoroscopically at least a part of it as it passes through the esophagus, in order not to overlook a lesion in this region, such as stricture or cardiospasm. The filled stomach is studied fluoroscopically for evidence of pylorospasm and for the character of the peristaltic waves. The stomach is usually palpated in an endeavor to fill the duodenum. However, this organ *rarely shows the typical caplike appearance in very young children.*

A colon injection is then given, using the same kind of opaque mixture that is used for adults, but in quantity proportionate to the size and age of the child. In a case of megacolon, which may have been disclosed in the course of the opaque meal examination, an unusually large amount of injection may be required. This may be determined by watching through the horizontal fluoroscope the injection flow into the bowel. Stereoscopic roentgenograms are made in the prone position, followed by single or stereoscopic exposures in the vertical position. In unusual cases, these may be supplemented by oblique or lateral exposures.

The child is then allowed to *eliminate the injection.* The amount of retention in the colon and the condition of the ileocecal valve are noted in exposures immediately after the elimination. In cases of dilatation of the cecum, the emptying of the sigmoid will allow the cecum to be observed much more clearly and remove all doubt of the shadow produced by an elongated sigmoid passing far to the right and overlapping the cecum.

Special study of the appendix may be made at 24-hour intervals, until it is empty.

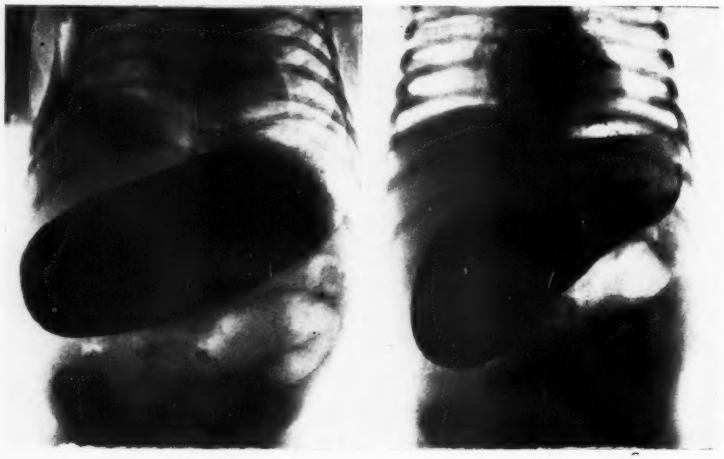
Among congenital anomalies of the esophagus, one of the most important is the type of atresia in which the lower end communicates with the respiratory tract, while the upper end terminates in a blind pouch. In view of the communication with the respiratory tract, it is evident that the performance of a simple gastrostomy is not sufficient to save these children. It is essential that the cardiac orifice of the stomach be tightly closed in order to prevent food from passing into the bronchi and causing pneumonia. Possibly a jejunostomy may accomplish a result more favorable than gastrostomy.

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

Later on, a plastic operation may be resorted to, in order to make a new esophagus out of a portion of the stomach, as has been done successfully after the removal of an esophageal tumor in an adult.

line, from which a narrow, tortuous channel emerges.

Cardiospasm, which has also been described as idiopathic dilatation of the esophagus, may be of congenital origin. Dr.



A *B*

Fig. 1. Congenital hypertrophic pyloric stenosis. Male, 8 weeks of age. Duration of symptoms, two weeks. Clinical diagnosis: pyloric stenosis or pylorospasm. Radiographic examination showed typical appearance of congenital hypertrophic stenosis. Stomach dilated *(A)* and at the end of 50 minutes none of the meal had passed through the pylorus *(B)*. An immediate operation was advised, but death occurred before preparations were completed. It is felt that if this case *had been x-rayed at the onset of the trouble* a successful diagnosis could have been made in time to have secured a favorable operative result.

Unfortunately, caustic substances such as lye, which is the basis of many cleansing preparations, are easily obtained by the public. A mother sometimes does not appreciate the danger of leaving one of these preparations open within reach of a child. Dr. Chevalier Jackson has repeatedly warned against this danger and has obtained successful legislation in many States requiring proper labels to be placed on such cleansing preparations as contain lye.

Strictures of the esophagus, due to the swallowing of caustics, usually occur in the middle third, and have a fairly characteristic appearance on roentgen examination. The upper portion of the esophagus appears dilated and ends in a more or less oval out-

Jackson claims that the condition generally known as cardiospasm is due, in many instances, to the failure of the diaphragmatic pinchcock to open at the proper moment in the deglutitory cycle. We have observed three such cases in children. In cardiospasm, the opaque mixture is seen to pass down to the cardia, at which point it stops. A roentgenogram made at this time, preferably in the oblique position, will show the outline of the esophagus to be smooth and regular, contrasting with the ragged shadow typical of newgrowth. The lower end of the esophagus will taper, rather than end in an oval pouch, as is observed in strictures from swallowing caustics. Usually it will be uniformly dilated above.

As early as 1912, it was suggested that it seemed only fair to obtain early a series of roentgenograms in every questionable case of *hypertrophic pyloric stenosis* (Fig. 1), so that the infant suffering from a true pyloric stenosis, with an obstructive tumor at the pylorus, might be referred to the surgeon while its physical condition was still good.

In a case with a palpable tumor in which, on repeated roentgen examination, there is a retention after three hours of the greater portion of the meal, surgical intervention is indicated, and the operation will not have been materially delayed. The roentgenograms afford a graphic demonstration to the pediatrician, who may find it expedient to utilize them in convincing the parents of the need of operation. Many lives have been lost through delaying operative relief until the child's resistance is so lowered that there is not sufficient vitality for him to react from operation.

Attention is called to the fact that roentgen examination demonstrates that the Fredet-Rammstedt operation is more desirable from a physiologic standpoint, inasmuch as the stomach empties at about a normal rate after the operation. After a gastro-enterostomy it usually empties at a much too rapid rate.

Roentgenographically considered, the term "pylorospasm" is used to indicate a pylorus which remains continuously closed for an unusual length of time after the ingestion of food, then relaxing, or one which intermittently opens and closes in an irregular manner. In either case there is apt to be a gastric retention beyond the normal emptying time. The cause of this condition can be ascertained readily in most cases. Pylorospasm will most often be found in children of spasmophilic tendencies. It may be entirely independent of the character or quantity of food ingested. We have observed in certain cases in which there is a mechanical derangement in the lower portion of the intestinal tract that there has been a corresponding delay in the emptying time of the stomach. This is borne out by experimental evidence. Because the older theories in regard to the acid control of the pylorus have been largely discarded in favor of direct control by the pyloric muscle itself, we are inclined to believe that there is some intrinsic lesion present.

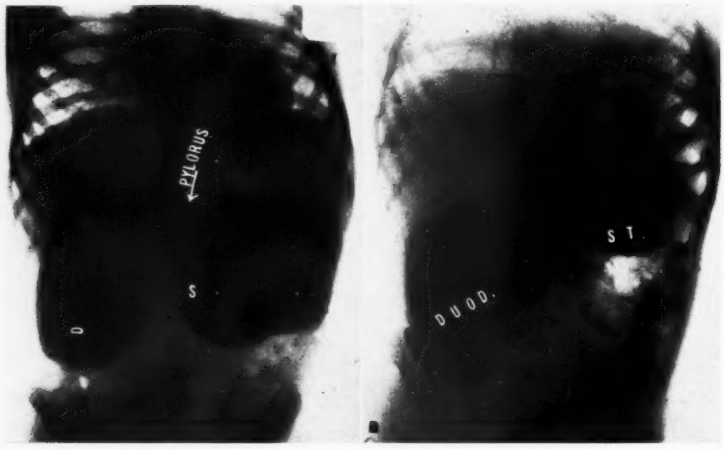
Cases of pylorospasm in older children usually come to the roentgenologist for study on account of recurrent attacks of vomiting, so-called "cyclic vomiting."

The typical roentgen findings of pylorospasm are about as follows: On the administration of an opaque meal the pyloric end of the stomach fails to fill. After several minutes, this region fills out, but nothing passes through the pylorus. (We refer to the unpalpated stomach, for, under forcible palpation in front of the fluoroscopic screen, some food may be pressed through the pylorus.) If roentgenograms are now made at intervals of 15 or 20 minutes, no food will be observed to pass through the pylorus until, perhaps, after from 45 minutes to one hour. From this time on, the pylorus may function in a fairly regular manner, so that, at the end of the average emptying time, only a slight retention may be present. In other cases, the pyloric aperture becomes spasmodically closed and does not relax again for another interval of from 45 minutes to an hour. In this type of case there will usually be a large gastric retention.

A considerable number of cases of recurrent vomiting have been entirely relieved by the knowledge afforded by a roentgen examination (Fig. 2). Defective intestinal mechanics and the associated pylorospasm are apparently indirectly responsible for the acute manifestations, such as fever and vomiting. The acetone breath and acetonuria due to temporary starvation gave occasion in the past to the diagnosis of

acidosis in these cases. To the best of our knowledge, these patients never showed air hunger or the extreme prostration associated with true acid intoxication. The fact that, after the establishment of suitable

That *gastroptosis* is frequently a congenital condition, or that at least the tendency to the condition is congenital, is shown by the illustration of a mother and two daughters, all of whom had a marked degree



A *B*

Fig. 2. Congenital dilatation of duodenum. Male, 4 years, 6 months of age. Periodic vomiting, abdominal distention. Radiographic examination showed an enormous pouch to the right of the stomach and equal to it in size *(A)*. The stomach was almost empty at the end of six hours, but the duodenum was more distended than before *(B)*. The duodenum was still filled at the end of *24 hours*. Diagnosis of dilated duodenum due to congenital obstruction was made. Successfully operated upon by Dr. W. A. Downes.

treatment, no recurrent vomiting seizures have occurred, would make us believe our diagnosis to be correct.

Prior to the use of the roentgen ray, it was generally believed that in an adult the normal position of the greater curvature of the stomach was considerably above the level of the umbilicus. This was substantiated by laparotomy, for, at operation, the patient is in the recumbent position. In the vertical position, however, a roentgenogram will show that the greater curvature may at times be several inches below the iliac crest. In a child this would be considered pathologic. Therefore, the only definite way of knowing the exact position of the stomach is by roentgen study in the vertical position.

of ptosis. It would be wise to examine for this condition more frequently, particularly if it be known that one member of the family has gastroptosis.

Grave *syphilitic* lesions are so frequently seen in children that it would seem advisable to keep in mind the possibility of this disease involving the gastro-intestinal tract. It is quite possible that such cases have been overlooked in the past.

The roentgen findings may be classified as follows:

1. Dumbbell-shaped deformity, due to infiltration of the middle of the stomach. This must not be confused with an hourglass deformity, which has an extremely narrow passage between the upper and lower

pouches. In syphilis, the diminished capacity of the stomach is usually compensated for by a dilatation of the esophagus.

2. Diminished size, without the dumb-bell-shaped deformity. In this type there is apt to be a rapid emptying, due to contractile failure of the pyloric sphincter. In spite of this, there may be a retention at the cardiac end at six hours, since the infiltrated wall is unable to function properly.

3. Involvement of the pyloric region somewhat similar to that of ulcer, causing stenosis with a resultant delay in emptying and dilatation of the stomach.

4. Filling defect about a portion of the stomach other than the pyloric end. In these cases the findings resemble those of newgrowth.

It is believed that dilatation and ptosis of the *cecum* have a congenital origin. The symptomatology has not been recognized in childhood, the associated digestive disturbances having been attributed to so-called acute indigestion, due to errors in feeding, or otherwise. To diagnose this condition requires not only a study by means of an opaque meal, but also by means of an opaque injection of the colon after the colon has been carefully emptied.

An *appendix* which fills with barium and empties readily does not deserve special consideration, but one which retains the opaque material *several days after the meal has been eliminated* from the colon is more than likely to be pathologic. These facts have been borne out in a series of cases operated upon successfully.

The presence of concretions in the appendix may be occasionally demonstrated without the aid of an opaque meal. However, one must distinguish between a concretion, a ureteral calculus, and a calcified gland, any one of which might cast a shadow in the right lower quadrant. A segmented appearance of barium in an appendix is probably due to the presence of concretions which have become coated.

Erroneous diagnoses of *acute* appendicitis have been made, and patients operated upon, in mistake for pneumonia on the right side. The physician must remember that pain associated with pleurisy or pneumonia may be referred to the iliac region.

Elongation or redundancy may occur in any portion of the colon, though the most frequent site is in the pelvic colon. The most evident symptom of a redundant (congenitally elongated) colon is that of fecal retention. The child comes to us with the history of persistent constipation requiring daily use of drugs or enemas. However, the condition may give no symptoms. In other cases, the elongated bowel may produce serious symptoms, namely, those of partial obstruction, intermittent in type, or complete obstruction from volvulus. We have found that pylorospasm is frequently associated with elongation of the colon.[2]

Megacolon: Congenital Dilatation of the Colon: Hirschsprung's Disease.—Roentgen examination not only makes or confirms the diagnosis in this condition, but, by means of a careful study, will frequently reveal the fact that the dilatation does not involve the entire colon. It may, for example, involve only the descending colon and sigmoid flexure. In other cases, the dilatation may involve separate portions of the colon, such as the hepatic flexure, splenic, or sigmoid flexure, or all three of these regions (Fig. 3).

Intussusception.—In a case of suspected intussusception, roentgen examination will, in all probability, locate the site of obstruction. Without even the administration of any opaque substance, roentgenograms may reveal distended loops of intestine, which, owing to the peculiar structure in the various regions, may lead to an identification of the intussuscepted bowel (Fig. 4).

Volvulus.—Cases of congenital dilatation of the colon, especially those associated with redundancy in the region of the sigmoid, are

[2]This may be of considerable importance in connection with the new nerve resection operation for megacolon.

Fig. 3. Megacolon in a male, 7 years of age. The patient had been extremely constipated since birth. X-ray examination showed enormously dilated hepatic, splenic, and sigmoid flexures. There was bilateral eventration of the diaphragm.

liable to suffer from volvulus. If the condition does not yield to medical treatment, it may be necessary to perform a laparotomy and relieve the volvulus by untwisting the loop of sigmoid. The operating surgeon might well consider the advisability of a radical operation, if the patient's condition permits of it.

The peculiar development of *non-rotation* of the colon has been encountered by us in 12 subjects. In this condition, the cecum is found, as a rule, on the left side, but it may be in the median line. Attention is called to the fact that the duodenum does not pass behind the transverse colon, passing instead directly to the right in almost a straight line, merging with the jejunum. On this account, the usual cap-like formation of the first part of the duodenum may *not* be evident. Lack of familiarity with this anomaly may lead to a wrong interpretation.

Roentgen examination has proved definitely that there is, in the stomach of every child, a variable amount of gas, derived from one of three sources, namely, swallowed air, gastric fermentation, and intestinal air, of which the first is by far the most common. A large amount of gas in the stomach at the time of feeding will almost invariably cause eructation or vomiting, because of excessive distention.

Hernia of the diaphragm is congenital in a large number of cases, though it often is not recognized until late in life. In many instances there is a history of trauma, and it is supposed that this has been the cause of the hernia. However, while this may occur, yet in many cases the hernia has been present, but unrecognized. The stomach may actually develop within the thorax, the esophagus entering the stomach above the diaphragm. On the other hand, in acquired hernia of the diaphragm, the esophagus enters the stomach below the diaphragm.

In some cases designated as "thoracic stomach," the entire stomach remains in the chest cavity; in others, part of the stomach is in the thorax and part in the abdomen. The latter is apt to cause attacks of partial obstruction. In addition to the stomach, the splenic flexure or other portions of the digestive tract may be in the chest cavity. We have studied two cases of hernia on the right side, in which the hepatic flexure had passed through the diaphragm. A hernia may protrude through a dilated esophageal opening. The mere presence of the stomach in the thoracic cavity is not in itself incompatible with the enjoyment of good health and longevity, provided the stomach functions normally. In one case of a woman 69 years of age, whose clinical diagnosis was carcinoma, there was present a congenital hernia of the diaphragm (thoracic stomach). Though she had been subject to intermittent attacks of pain for 30 years, at the time of examination her physical condi-

tion was exceptionally good. When asked to locate her pain, she placed her hand over the lower part of the chest exactly where the roentgen examination showed the stomach to be.

Tuberculous peritonitis is often suggested roentgenographically by a delay in the passage of food through the small intestine, the presence of dilated loops in this region of the bowel, with a peculiar tendency to pocketing of food in these loops, and by findings suggestive of adhesions between parts of the small intestine.

In *tuberculous enteritis* one would expect to find unusually rapid progress of the opaque meal through the intestine, in view of the presence of tuberculous ulceration. However, the ulceration may cause infiltration and stenosis which would result in a delay in the small intestine.

The tuberculous ulcers may be accompanied by localized tuberculous peritonitis causing adhesions. This might produce localized areas of dilated loops of small intestine.

Transposition of the viscera is much more frequent than was previously thought to be the case. This is due to routine roentgen studies, for former cases were seen only by chance at autopsy. The author has encountered 39 cases, the youngest being four months of age.

As a rule, if one viscus, such as the heart, is transposed, the other viscera are also transposed. The transposition is usually so complete a reversal of the normal that care must be exercised always to mark roentgenograms in such a manner that the right and left side can be definitely identified. This is especially true since the use of double-coated films has become so general. Previously, one could determine the right and left from the emulsion side of the plate, knowing the position in which the exposure was made.

It is possible to have a combination of transposition of the viscera and non-rotation of the colon. The appendix would then be

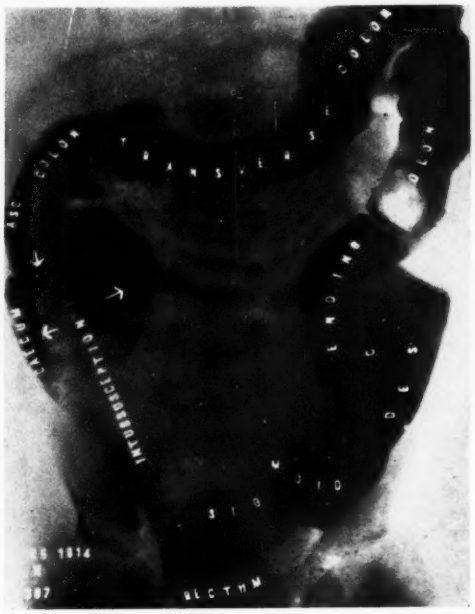


Fig. 4. Intussusception. Male, 16 months of age. Symptoms of intestinal obstruction of 24 hours' duration. There was no palpable mass. Clinical diagnosis: *suspected* intussusception on the left side. Radiographic examination disclosed intussusception of the terminal ileum into the cecum. The injected opaque material when it met the intussuscepted portion of the ileum spread out over it in a thin layer. A small incision was made directly over the cecum, the intussusception was reduced, and complete recovery resulted.

in the mid-line or on the right side, in spite of the transposition. While the occurrence of this anomaly has not been personally observed, reports of two cases have been brought to the writer's attention which, from the description, would lead one to believe they represent this condition.

A case of displaced heart should never be mistaken for transposition. Roentgen evidence is usually conclusive on this point, first, because the cause of the displacement, in this instance a pneumothorax, is usually evident; secondly, a transposed heart is, as a rule, accompanied by transposition of the stomach. The location of the stomach may be definitely determined by means of an opaque meal or simply by the presence of gas in the cardiac end.

The correct diagnosis of abdominal *tumors* may be greatly aided by careful roentgen examination. While it is occasionally necessary to have a combined urologic and roentgen examination, it is rarely necessary to produce an artificial pneumoperitoneum, or perirenal emphysema.

In a given case of palpable abdominal tumor, the roentgenologist usually starts the examination with anterior and posterior roentgenograms before the administration of an opaque meal, in order to determine the presence of calcified deposits or dilated areas of the digestive tract. The opaque meal is then carefully followed to determine the possible relationship of the tumor to the digestive tract. Certain tumors produce characteristic displacement, *i.e.*, an enlarged spleen displaces the splenic flexure downward, while tumors of the kidney displace the descending colon forward and inward.

Foreign bodies may lodge in the pharynx or esophagus of an infant or young child, remaining there for some time unsuspected, unless the swallowing of the foreign body has actually been observed. The child may refuse his food, appear restless, and have a more or less spasmodic cough. In any obscure case of this sort, a roentgen examination should be made, as metallic foreign bodies are so easily detected. In the absence of a shadow of a metallic foreign body the symptoms may be persistent enough to warrant an esophagoscopic examination, which may disclose a non-metallic foreign body as the cause of the symptoms. On the other hand, the foreign body may pass directly into the stomach.

Foreign bodies may be divided into two classes:

1. Those which are more or less harmless and may be roentgenographed from day to day in order to watch their progress through the intestinal tract. Under this heading are included coins, buttons, closed safety-pins, etc., the immediate removal of which is not imperative.

2. Foreign bodies such as needles, open safety-pins, and all pointed metallic substances, if repeated roentgen examinations show that they remain in the stomach for several days, should be removed through the gastroscope or through a gastrotomy opening.

The successful passage through the pylorus of foreign bodies which have one sharp and one blunt extremity is accomplished by the blunt end passing first. If the point attempts to pass first through the pylorus, apparently a strong spasm is set up which prevents the point passing further. The alternate relaxation and contraction of the stomach then tends to perform a "version." When the *blunt* end finally reaches the pylorus it is allowed to pass. This mechanism has been observed in a number of cases.

If the foreign body passes through the pylorus, it will, in most instances, successfully pass through the remainder of the digestive tract, *but this can never be taken for granted.* A long metallic foreign body may lodge in the duodenum, and removal is demanded if it appears to remain stationary for several weeks. Delay as long as two weeks may be observed about the cecal region, before the onward movement of the foreign body finally occurs. If, after two weeks, no change is observed in the position of a foreign body in a roentgen examination, operative intervention is usually advisable. Round, or short, pointed objects sometimes lodge in the appendix. Three cases of birdshot have been observed in the appendix and several patients with pins.

Another foreign body in the stomachs of older children and young adults, which can hardly be classified with either of the preceding groups, is a *hair-ball.* This condition is usually the result of a habit of pulling out individual hairs and swallowing them.

A case was recently encountered of a foreign body in the stomach, the patient denying any knowledge of when or how it had

been swallowed. On removal through the gastroscope, the metallic foreign body was found in a condition that would indicate its presence in the stomach for a period of perhaps many months. In commenting on this case Dr. Chevalier Jackson has written to me assuring me of his belief in "the necessity of every man, woman, and child having an x-ray examination periodically as part of the general examination every year."

CONCLUSIONS

1. Every newborn baby should have an x-ray examination made of its digestive tract, as well as of its heart, lungs, and osseous system, including the skull.

2. A periodic health examination is never to be regarded as complete unless it is accompanied by an x-ray examination.

3. Before undertaking a surgical operation for supposed chronic appendicitis, an x-ray examination is advisable in order that the location of the appendix, or at least the cecum, may be determined, as over 50 cases of left-sided appendix have been observed by the writer. Furthermore, definite information may be obtained confirming the diagnosis of chronic appendicitis, or some other condition may be found to account for the symptoms and make surgical intervention unnecessary.

DIAGNOSIS OF EXTRA-GASTRO-INTESTINAL ABDOMINAL MASSES[1]

By LEO G. RIGLER, M.D., MINNEAPOLIS, MINNESOTA

From the Departments of Radiology of the University of Minnesota and the University Hospital, Minneapolis

THE determination of the presence, size, shape, position, and origin of a mass in the abdomen is a problem which has always intrigued medical men. While in some cases the answers to these questions may be readily obtainable from the history and physical findings, frequently these methods alone are insufficient. Hardly a more difficult task faces the clinician than that of deciding whether or not he feels an abnormal mass and, if so, whether it is intra- or retroperitoneal in situation, pelvic or upper abdominal in origin, and to which organ it is attached.

This diagnostic problem, no doubt, led to the discovery and use of pneumoperitoneum in roentgen diagnosis. It has led to many other methods of rendering an abdominal viscus or mass visible by the use of contrast media. The roentgen visualization of the gastro-intestinal tract, the urinary tract, the gall bladder, the uterus and tubes, and now the liver and spleen have all been steps in the advancement of the diagnosis of abdominal masses.

The most recent development, the rendering of the liver and spleen opaque to the roentgen rays by the intravenous administration of thorium dioxide in colloidal suspension, holds forth great promise in this direction. If the accurate determination in the roentgenogram of the liver and spleen can either eliminate them from consideration or demonstrate either as the source of a palpated mass, a great deal will have been accomplished. In our limited experience with this method, a number of obscure cases have already been clarified in this way. Obviously, the procedure has numerous other applications, such as the study of the func-

[1]Presented before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

tion of the liver and spleen, the effects of disease upon these two organs, and many others, but not the least part of its value is the clear outline of the liver and spleen which may now be obtained.

Fig. 1. Markedly enlarged spleen in case of myelogenous leukemia. The medial border of the spleen can be outlined by the shadow of the greater curvature of the stomach. The latter is displaced markedly to the right but a small portion (arrow) protrudes to the left, obviously projecting into the splenic notch. This is an exaggerated picture of the characteristic displacement of the stomach by an enlarged spleen. (Confirmed clinically.)

The intraperitoneal injection of gas is, no doubt, the most valuable and accurate method of demonstrating an abdominal mass. The objections to it lie in the fact that it is not a simple procedure, involves considerable distress for the patient, and is not entirely without risk. Nevertheless, when simpler methods fail, it should be resorted to, by all means. The simplest procedure which is helpful consists of the roentgen study of the gastro-intestinal tract with the use of an opaque medium.

In many cases the examination of the stomach and bowel with the barium meal and of the colon with the barium enema, or by air inflation, is sufficient to give data leading to the accurate diagnosis of any abdominal mass. In view of the fact that in most cases this examination would, in any event, be made to rule out the gastro-intestinal tract as a source of the tumor, it is surprising that not more has been written concerning this method of diagnosis. Reference to it in text-books is meager and the only recent papers in English on this subject are those of Butler and Ritvo (1) and Brown (2). The former have covered the subject most completely while Brown has emphasized the importance of the lateral view.

The method of procedure consists in the roentgenoscopic and roentgenographic examination of the stomach and bowel after a barium meal at frequent intervals and in numerous positions, both upright and prone. The roentgenoscopic examination permits manipulation of each individual case to the best advantage, and films are then made in the positions best calculated to demonstrate the abnormality which is present. The same method is used in the examination of the colon, the barium enema being not infrequently supplemented by inflation with air. The latter often permits a more accurate delineation of the mass, the density of which stands out in sharp contrast to the surrounding gas-filled bowel. Frequently, especially in children, sufficient gas is present spontaneously in the colon to enable delineation of a mass in the roentgenogram without further manipulation.

Abdominal masses, whether they be enlargements of an abdominal viscus or ex-

traneous tumors, will usually produce some deformity or displacement of that portion of the gastro-intestinal tract with which they are in contact. Obviously, considerable increase in the size of the organ must occur before this displacement is of sufficient grade to permit visualization. In most cases, however, when symptoms are present, or a mass palpable, the displacement is well marked. In fact, during the course of a routine examination of the gastro-intestinal tract, we have frequently been enabled to call attention to the presence of an extra-gastro-intestinal mass which was entirely unsuspected clinically. It must, of course, be borne in mind that normal abdominal organs may produce distinct impressions upon the stomach or bowel. The normal spleen, for example, particularly in asthenic individuals, frequently indents the greater curvature of the stomach or the splenic flexure of the colon. Likewise, the normal liver may compress the hepatic flexure of the colon, while a normal gall bladder may produce a distinct impression on the duodenal bulb. The urinary bladder, when filled, often displaces the small bowel out of the pelvis and may thus be mistaken for a pelvic tumor. The estimation of whether or not the degree of displacement is abnormal is a matter of judgment, although in most cases no great difficulty is experienced. A knowledge of the normal position and the relationship of the solid abdominal organs to the gastro-intestinal tract and peritoneum is necessary in order to properly analyze the character of the displacement and deduce therefrom the nature of the mass which is causing it. Furthermore, it must be considered that various organs, when they enlarge, tend to extend in fairly characteristic fashions. Thus the spleen, while it is a partially posterior organ, enlarges anteriorly. The kidney, on the other hand, tends first to enlarge posteriorly. Similar characteristics are manifested by the other organs.

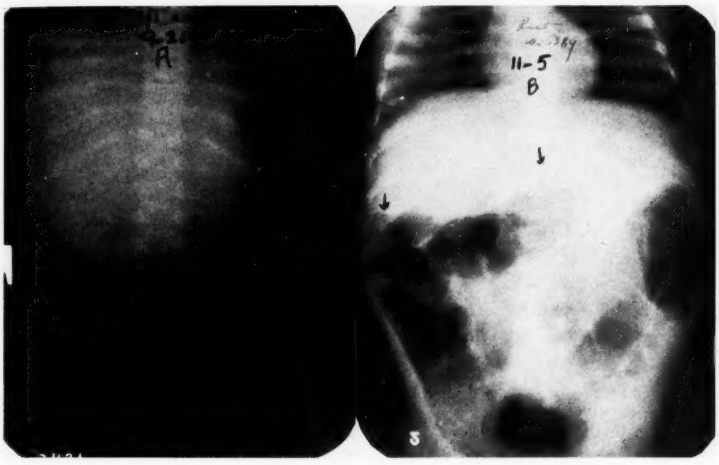


Fig. 2-*A (left)*. Congenital cyst of liver. The enormous size of the liver is well shown by the displacement of the hepatic flexure and transverse colon into the pelvis. The size of the liver can be fairly well made out by the contrast of the spontaneously gas-filled colon (arrows). (Confirmed at operation.)

Fig. 2-*B (right)*. Same case after surgical drainage. Only a small remnant of liver substance remained but this rapidly regenerated. The changing size of the liver could be readily followed by observing the position of the gas-filled colon (arrows). At this stage the liver is still smaller than normal.

Fig. 3. Hydrops of the gall bladder of large size. The stomach (1) and duodenal bulb (2) are displaced to the left, the latter being compressed upon the antrum (1) of the stomach. The second portion of the duodenum (3) is displaced to the left. The hepatic flexure (4) is displaced to the right. The area (5) in which no barium is seen represents the gall bladder. Its size, shape, and position are thus readily outlined. (Confirmed at operation.)

For the purposes of roentgen diagnosis the abdominal masses may best be classified into four groups, as follows: (1) upper abdominal intraperitoneal masses including spleen, liver, gall bladder, and tumors in this region; (2) pancreatic tumors, or cysts, and retroperitoneal upper abdominal glands; (3) retroperitoneal masses including the kidneys; (4) masses of pelvic origin. In this study, tumors arising directly from the gastro-intestinal tract are not considered. Each of these groups exhibits certain characteristics in its displacement and compression of the gastro-intestinal tract. The individual organs or tumors within each group may also have more distinctive manifestations.

It would seem that palpation of the spleen would be undisputed by clinicians, yet numerous cases arise wherein the distinction between the spleen, the left kidney, a subphrenic abscess, and tumors arising from the peritoneum is apparently difficult. The spleen characteristically displaces the stomach to the right, compresses the greater curvature, and may even exhibit its notch by the peculiar formation of the greater curvature of the stomach (Fig. 1). The splenic flexure is normally displaced downward but not necessarily so, as the spleen may displace the descending arm of the flexure to the right while leaving the superior margin of the colon under the diaphragm. The fact that the spleen is always above and lateral to the colon and that it displaces the cardiac end of the stomach as well as the middle portion, effectively distinguishes it from the left kidney. The left lobe of the liver commonly compresses the anterior wall and the lesser curvature of the cardiac end of the stomach. Tumors arising from the peritoneum may also affect the anterior wall or, if pressing on the greater curvature of the stomach, may permit the splenic flexure of the colon to go untouched, thus distinguishing themselves from the spleen. Subphrenic abscess, while rare on this side, may cause displacement of the splenic flexure. It commonly immobilizes the diaphragm, displaces it upward to a great extent, and is less sharply defined than the shadow of an enlarged spleen.

Enlargements of the liver characteristically push the stomach and duodenum downward and to the left, while they compress the duodenal bulb and the lesser curvature of the stomach. The clinical distinction of liver enlargements from pancreatic cysts or tumors occasionally produces some difficulty. Lateral views will show the mass distinctly anterior to the stomach and displacing it backward. Enlargements of the left lobe of the liver may produce a striking compression of the cardiac end of the stomach. Enlargements of the right lobe characteristically displace the hepatic flexure downward. In many cases the size of the liver may be delineated with fair accuracy

by this relationship with the colon. For example, in a case of congenital cyst of the liver, which was surgically drained, the exact size of the liver could be followed with considerable certainty by observing the position of the gas-filled hepatic flexure and transverse colon. The original condition in this case is shown in Figure 2-*A*, the right half of the colon being shown well down in the pelvis, with the dense shadow of the liver cyst above it. After drainage of the cyst, hardly any liver tissue remained, but within a few weeks regeneration took place and the restoration of the normal relationship is shown in Figure 2-*B*. The colon is here obvious, well up out of the pelvis, embracing the inferior surface of the liver, which is probably still somewhat smaller than normal. The author has been enabled on several occasions to make a presumptive diagnosis of atrophic cirrhosis of the liver in patients who were being examined to rule out carcinoma of the stomach. In these, the greatly reduced size of the liver was obvious by the high position of the hepatic flexure of the colon. Occasionally this flexure passes completely upward to the diaphragm, simulating a subdiaphragmatic accumulation of gas. This is due to a posterior displacement of the liver rather than to any decrease in its size, and should not be confused with atrophy of the liver. The lateral view will demonstrate in these cases that the colon lies anterior to the liver rather than below it.

While moderate enlargements of the gall bladder may show displacement or compression of the duodenal bulb, the so-called gallbladder "seat" is not always indicative of abnormality. Hydrops of the gall bladder, however, may produce a hard, rounded, protruding mass which often cannot, by palpation alone, be distinguished from other tumors. Such a case is illustrated in Figure 3. The tendency to displace the duodenum and antrum of the stomach to the left and the hepatic flexure to the right is here well

Fig. 4. Carcinoma of head of pancreas. At this stage, this case was clinically diagnosed as cholecystitis. Note compression of superior surface of bulb (arrow) by enlarged gall bladder. The duodenal curve is widely opened up, the second portion being pushed to the right, the third portion downward, while the stomach and bulb are displaced upward and to the left. The tumor is thus clearly outlined. Later actual invasion of the duodenal bulb could be demonstrated. (Confirmed at operation.)

shown. The duodenal curve is compressed, in contrast to the effect of tumors of the head of the pancreas which tend to open this curve widely. This case also illustrates an important finding which is usually of considerable significance. There is a complete absence of barium in a portion of the abdomen which normally contains bowel. When the barium meal is given in such a way that the stomach, small bowel, and colon are all visualized at one sitting, the conspicuous absence of the contrast medium in any particular part of the abdomen, except the right upper quadrant, has often led to the roentgen detection of a clinically unsuspected, abnormal mass.

Omental cysts, while rare, may cause marked posterior displacements of the stomach. These are best observed in the lateral view. The distinction from enlargement of the liver is often very difficult. Mesenteric

Fig. 5. Cyst of body of pancreas. A massive filling defect of the middle and pyloric thirds of the stomach is shown. By placing the patient in various positions, the posterior and inferior position of the mass could be demonstrated. The defect changed its form, and filling could be obtained with the patient lying on the right side, while peristalsis passed through the whole area. An intrinsic tumor was thus excluded. (Confirmed by operation.)

cysts tend to displace the stomach upward and forward, depending somewhat upon the portion of the mesentery from which they arise.

Diseases of the pancreas still remain one of the major diagnostic problems which confront the physician. Frequently, however, tumors and cysts of the pancreas give characteristic roentgen findings. Carcinoma of the head of the pancreas tends to cause enlargement of the duodenal curve, the first portion being pushed to the left and upward, the second portion to the right, while the third portion is pushed downward (Fig. 4). Obviously, the tumor must attain an appreciable size before this effect is produced. Occasionally actual invasion of the duodenum itself occurs, with a resultant deformity which may be difficult to distinguish from an intrinsic tumor. In Figure 4 is shown an illustrative case, the x-ray findings being present at a time when clinically the diagnosis was quite unsuspected. We have found this displacement of the duodenum of great value in about half the cases of carcinoma of the pancreas which have come under our observation. Many cases of carcinoma of the head of the pancreas show definite clinical findings at a time when no real mass exists, the malignancy infiltrating the organ rather than expanding it. In these cases no roentgen findings will be made out. In a recent case the roentgen findings indicated clearly an enlargement of the liver, while the duodenum was undisturbed. At autopsy a diffuse carcinoma of the pancreas was found, with massive metastases to the liver, the latter being responsible for the roentgen findings. These observations must, therefore, in these cases as in all others, be considered together with all the clinical data in arriving at a diagnosis.

Tumors of the body and tail of the pancreas tend to displace the stomach upward and forward, the transverse colon downward. The normal close relationship of the greater curvature of the stomach and the transverse colon is thus disturbed, the two being separated. Cysts of the pancreas may give a striking picture, as shown in Figure 5, a marked deformity of the stomach resulting. An intrinsic lesion of the stomach could be ruled out by changing the position of the patient, the defect then diminishing in size or disappearing, while peristalsis could be followed through the compressed area. Occasionally, cysts occur in the head of the pancreas and tend to compress the antrum of the stomach as well as expand the duodenal curve. Rarely a pancreatic tumor may extend upward behind the stomach to produce pressure on the lesser curvature. These cases resemble liver enlargements, but the posterior position of the mass can be demonstrated in the lateral view because of the

anterior displacement of the stomach, thus tending to make the distinction clear. I have observed three cases of pancreatic cyst in all of which this anterior displacement of the stomach was most striking.

It seems evident that retroperitoneal lymph nodes of the peri-aortic group, in the upper abdomen, may produce a similar appearance to that described above. Usually, however, the defect in the stomach is not so regular or sharply defined because of the lobulated character that glandular masses assume; but the differentiation of these lymph node tumors from enlargements of the pancreas, by the roentgen examination alone, is often most difficult.

Other retroperitoneal masses, such as kidney tumors and enlargements, adrenal tumors, and retroperitoneal sarcomas, are quite different in that they are more likely to be unilateral and lie well to one side of the spine instead of in the midline, as is the case with pancreatic or peri-aortic lymph node enlargements. While the stomach may be displaced upward and its greater curvature impinged upon by left-sided retroperitoneal masses, the anterior displacement is more striking. The chief effect of this group is to displace the small bowel and colon, depending upon the size of the mass. Most commonly, if the mass is not exceptionally large, the bowel remains in a relatively normal position medio-laterally, but is displaced to a marked degree anteriorly. This can best be demonstrated in the colon either by means of a barium enema or by air inflation. Examination in the lateral or oblique positions will demonstrate the anterior displacement of the ascending or descending colon, depending upon whether the mass is on the right or left. This is well demonstrated in the case shown in Figure 6, in which the cecum and ascending colon are compressed and displaced anteriorly by a tumor of the right kidney. If the mass becomes very large, it may displace the small bowel completely out of this segment of the abdomen and push the colon medially, or even downward. Downward displacement of the hepatic flexure by a right-sided retroperitoneal tumor of large size may simulate an enlarged liver in the postero-anterior view. The lateral view, as shown above (Fig. 6) will normally make the distinction. Occasionally a lateral displacement also occurs but this is much less common. It is notable that on one examination the colon may lie over the mass showing only anterior displacement, while re-examination a short time later may show the colon displaced entirely out of the field occupied by the tumor. Obviously, no sharp distinction can be made in this way between kidney enlargements

Fig. 6. Hypernephroma of right kidney. Lateral view of colon showing marked anterior displacement of the cecum and ascending colon. The tumor can be well outlined (arrows). Compare with Figure 8. (Confirmed at operation.)

Fig. 7. Sarcoma of right ovary. Lateral view shows marked posterior displacement of cecum and ascending colon (arrows). Note the appendix projecting posterior to the plane of the vertebral bodies (arrow). Compare with Figure 6. This posterior displacement is characteristic of large intraperitoneal masses. (Confirmed at operation.)

and other retroperitoneal masses. If, however, the retroperitoneal nature of the mass is clearly established, further investigation by means of intravenous or retrograde pyelography may establish the connection or innocence of the kidney.

Displacement of the ureter is an excellent indication of the retroperitoneal location of any mass. Kidney tumors and other enlargements frequently displace the ureter but other retroperitoneal tumors lying lateral to the ureter also displace it, usually toward the spine. While it is true that very large intraperitoneal tumors may penetrate posteriorly to a sufficient degree to displace the ureters, this is relatively infrequent, the displacement being likely to measure small in proportion to the size of the mass, and both ureters may be equally affected, the displacement being lateral.

Pelvic tumors, such as arise from the uterus, Fallopian tubes, ovaries, and bladder, are usually quite obvious clinically. Nevertheless, cases arise in which the distinction between a massive retroperitoneal tumor and one arising intraperitoneally from the pelvic organs is extremely difficult. The method of surgical approach and the surgical indications being different, the differentiation becomes of considerable importance.

A filled urinary bladder may be clearly outlined by the displacement of the small bowel out of the pelvis: the pregnant uterus produces a somewhat similar effect. The colon, however, may give a clearer indication. Compression of the sigmoid flexure downward and laterally usually occurs if the tumor arises on the left. The descending colon will be displaced posteriorly and laterally, the transverse colon and stomach upward. If the tumor arises on the right the cecum and ascending colon will be displaced upward and posteriorly. If the tumor is in the mid-line and of large size, such as a myoma of the corpus uteri, both effects may be produced. The lateral view, again, as pointed out by Brown (*2*), is of great importance, particularly in the more massive tumors. A case of ovarian sarcoma is well illustrated in Figure 7. The right side of the colon is displaced posteriorly to a large degree, the appendix being visualized behind the plane of the vertebral bodies. This case may be contrasted with that shown in Figure 6, in which the colon is displaced anteriorly by a retroperitoneal mass. Great care must be exercised in the interpretation of these lateral views because of the superimposition of the descending and ascending portions of the colon in this position. Very

large pelvic tumors tend to extend upward and thus to separate the flexures of the colon and to displace the ascending and descending portions laterally as well as posteriorly. It may be well to emphasize again that these changes may often be observed as well or better by gas inflation of the colon as by the barium enema. Figure 8 illustrates such a case wherein the gas-filled colon and small bowel outline well the upper limits of the ovarian cyst which is displacing them out of the pelvis. In the standing position, pressure on the greater curvature of the stomach may also be demonstrated. The cyst of the ovary in this case is flattening the inferior portion of the greater curvature by the pressure exerted upon it.

It is necessary to add that many errors creep into this method of diagnosis of abdominal masses. The procedure does not even approach the accuracy of the roentgen diagnosis of intrinsic gastro-intestinal lesions. As has been pointed out above, the rules which have been formulated from a study of a large number of such masses do not always hold. Interpretation, particularly of the lateral views, is often difficult. Nevertheless, an intelligent application of our knowledge of the anatomy of the abdomen, and of the usual behavior of abdominal masses, to careful roentgenoscopic and roentgenographic studies of the whole gastro-intestinal tract in different positions, will frequently result in the most accurate delineation of the size, shape, location, and origin of extra-gastro-intestinal tumors.

Fig. 8. Cyst of ovary. The pelvic mass is seen displacing the bowel and colon upward. These are distended with gas, and barium is unnecessary to demonstrate the position of the bowel. Note how well the tumor mass is outlined (arrows).

SUMMARY

The roentgen examination of the stomach and small intestine with the barium meal and of the colon with the barium enema, or by air inflation, is a valuable aid in the diagnosis of extra-gastro-intestinal masses. Occasionally, tumors which were clinically unsuspected may be revealed in this way.

The enlargements of the various abdominal organs and abdominal tumors tend to produce compression and displacement of the stomach and bowel. The character of this displacement depends upon the characteristics of the individual mass. For this reason, the size, shape, origin, and position of a tumor can frequently be determined by its effect upon the gastro-intestinal tract.

The general characteristics of the various groups of abdominal masses and of their individual constituents are detailed. Cases are cited to illustrate how helpful this simple procedure may be in obtaining valuable information concerning many abdominal masses.

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DISCUSSION

DR. SAMUEL BROWN (Cincinnati, Ohio): I have been quite interested in this work for several years and have succeeded in making accurate interpretations of lesions outside the stomach in quite a number of cases in which the usual clinical and physical methods have failed. In my work I depend upon one anatomic characteristic of the stomach—its mobility. The stomach is, relatively speaking, a freely movable organ. Its position will, therefore, depend upon the condition of its neighboring organs. Thus, an enlargement of the spleen will displace the stomach forward and to the right. An enlarged left kidney will do the same; but, in the former, the splenic flexure is also displaced, while in the latter, the splenic flexure remains in normal position. An enlarged right kidney will displace the stomach to the left and forward: an enlarged liver will displace it to the left and backward: an enlarged pancreas or a retroperitoneal tumor will displace it forward. If any lateral displacement is present, the stomach is usually displaced to the left and the duodenum to the right.

DR. N. ENZER (Milwaukee, Wis.): I wonder if Dr. Rigler has had any experience with chylocysts (lymphogenous cysts) of the omentum. Do they produce pressure defects in the stomach or intestinal shadows?

DR. LAWRENCE LITTIG (Madison, Wis.): Both the previous speakers mentioned the displacement of the duodenum to the right and the stomach to the left in tumors of the head of the pancreas. Some time ago I had such a case, and felt sure it was a tumor, or cyst, at the head of the pancreas. However, it proved to be a lipoma of the omentum which gave this typical deformity. Occasionally this will occur.

DR. RIGLER (closing): I think I mentioned that we have used thorium dioxide, which gives brilliant visualization of the liver and spleen, in a limited number of cases. We have not given enough to enable us to draw conclusions as to its eventual value.

We had a case not long ago in which all the clinicians, except one, agreed they could feel the spleen. This spleen, as demonstrated by the thorium injection, was so small they could not possibly have felt it. That is not an uncommon instance.

I did not explain why the patient with myosarcoma had such acute symptoms. They were due to bleeding into the cyst.

I have seen an omental cyst, not a chylous cyst, which simulated very closely an enlarged liver, and displaced the stomach backward to some extent.

I have used only a small group of the cases which I thought more closely illustrated the type of condition one could meet. I have seen several cases in which clinicians have had great difficulty in distinguishing a large liver and a pancreatic cyst. In our experience this distinction is not easy to make. Because of the posterior displacement of the stomach with the large liver, in contrast to the displacement along the greater curvature of the cyst, we are able to make the diagnosis.

One case in which we thought there was carcinoma at the head of the pancreas, with that characteristic curve, came to autopsy, and we found edema of all the tissues without involvement of the pancreas.

It is difficult to see how a lipoma of the omentum would not manifest itself as in an anterior position, in contrast to the head of the pancreas, relatively posterior. That is the only differential. All of these findings have none of the accuracy of the roentgen diagnosis of carcinoma of the stomach. When we make a roentgen diagnosis of carcinoma of the stomach, we are so sure of it that we rely on it almost 100 per cent. In extra-gastro-intestinal lesions, of course, the certainty of the diagnosis does not approach that, but the roentgen diagnosis is helpful when you consider all the other signs.

CHANGES IN SUSCEPTIBILITY OF *DROSOPHILA* EGGS TO X-RAYS

I. A CORRELATION OF CHANGES IN RADIOSENSITIVITY WITH STAGES IN DEVELOPMENT

By P. S. HENSHAW, Ph.D., and C. T. HENSHAW, B.S., Biophysical Laboratory, Memorial Hospital, NEW YORK CITY

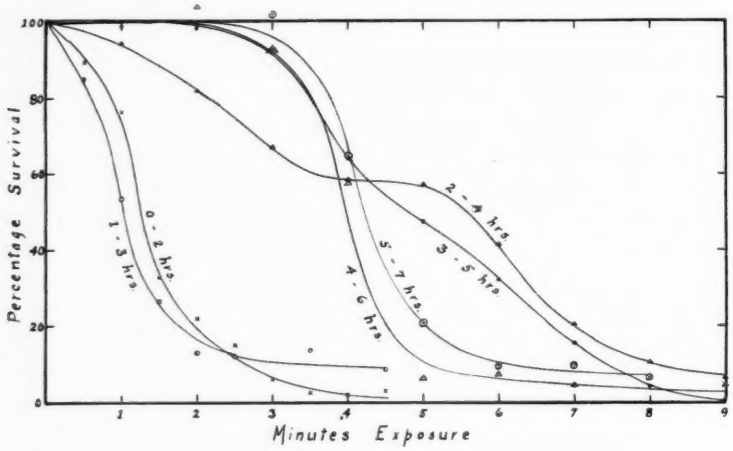
THAT tissues and organisms differ widely among themselves in radiosensitivity has long been recognized, but comparatively little, it seems, is known of how any one tissue or organism may change in susceptibility to radiation with respect to time or age. While studying the killing effects of x-rays on *Drosophila melanogaster* eggs, certain irregularities in results were obtained. An investigation showed these to be due mainly to the age of the material used. The determination of the significance of the age factor served not only as a foundation for other work in which *Drosophila* eggs were to be used as test material, but also to show how an organism may vary in susceptibility to radiation during development. Since certain stages in the early development of this form are distinct and easily recognizable, it is possible to associate the changes in radiosensitivity with the stages in development and thus ascertain whether or not the nature of the activity going on within the organism is important in determining its response to radiation. At this time we wish to correlate the changes in radiosensitivity with the stages in development and point out the possible influence of the age factor when *Drosophila* eggs are used as test material, leaving for a subsequent report a discussion of the kinds of developmental activity associated with the changes in radiosensitivity.

EXPERIMENTAL PROCEDURE

Culture of Flies.—The stock was reared on a molasses-cornmeal medium, the same used by Packard (described by Wood (1) and Packard (2)). The medium was poured into large-mouthed 12-ounce bottles to a depth of about 2 centimeters. Before this mixture was allowed to cool, cellucotton strips (approximately $2 \times 4 \times \frac{1}{4}$ inches) were inserted, one to a bottle, so that one end dipped into the cornmeal mass. When the mass congealed, the cellucotton was held firmly, protruding up along one side of the bottle. This served to absorb the moisture which had a tendency to condense on the walls of the bottles when in use for culture purposes, and to give dry rough surfaces for the flies to crawl over. Loosely rolled cellucotton was used also for stoppers, made long enough to extend well into the bottles. These permitted a free gaseous interchange between the air in the bottles and the outside air, also absorbing the moisture and giving more of a dry surface for the flies. Thus arranged, the bottles were ready for use as soon as the food mass had cooled to room temperature (from 21 to 25° C.).

Eggs were collected according to the method to be described below and transferred on moist filter-paper strips to the bottles, each bottle receiving between 300 and 600 eggs. When kept at room temperature the eggs began to hatch in about 20 hours. The emergent larvæ grew in size, and, during the second day after the eggs had been placed in the bottles, the larvæ could be seen crawling in search of food. At this time yeast cake (Fleischmann's) was made semifluid by mixing with tap water, and 4 or 5 c.c. were squirted from a pipette onto the sides of the bottle so that

it ran down onto the medium. Usually immediate excitement was displayed by the larvæ as they oriented themselves and began to move toward the food. From this time until pupation occurred the larvæ ate the adult flies emerged. Since the eggs were of approximately the same age, most of the adults appeared within a period of 24 hours. Those slow in emerging were never saved. The young adults were transferred



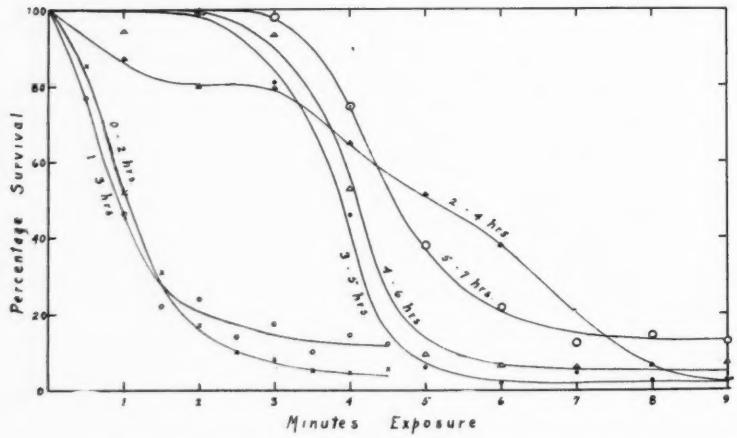


Fig. 1. Survival curves for eggs of different ages. Exp. I.

Fig. 2. Survival curves for eggs of different ages. Exp. II.

large quantities of the yeast. Since their growth and adult size are dependent upon the amount of food consumed at this time, ample amounts were kept available.

After four or five days in the pupal stage to fresh culture bottles (from 75 to 150 to a bottle) and provided with what may be called "adult food," since it differs from the yeast fluid "larvæ food." The adult food consisted of two parts of ripe banana and

one part of yeast mixed to form a pasty fluid. Fresh culture bottles were supplied every two or three days.

Collection of Eggs.—Adult flies from 3 to 6 days old were transferred from three culture bottles to a clean dry bottle which did not contain food. Into this also was inserted a glass slide on which lay a strip of filter paper moist with adult food. The bottle was then stoppered and put away for two hours (horizontal position with moist filter paper directed upward). During this period the flies usually deposited several hundred eggs on the filter-paper strip.

For the experiment it was necessary to have large samples of eggs of different ages. Accordingly, enough collecting bottles were arranged to yield enough eggs for any particular age sample during a two-hour period. By using the same flies repeatedly, a sample of eggs was obtained every two hours. To obtain samples every hour a second set of collecting bottles was arranged to alternate with the first. Thus after seven hours' collection, six samples of material were available, ranging in age as follows: 0-2, 1-3, 2-4, 3-5, 4-6, and 5-7 hours from the end of the collection period.

Since we were concerned with age relative to development rather than to the end of the collection period, and since development begins with fertilization, we were interested in age beginning at the time of fertilization. Because of the nature of the material, however, it is not possible to state precisely the time of fertilization. In *Drosophila* the eggs are fertilized individually as they pass through the vagina of the female fly. Usually they are laid immediately after fertilization, but may be retained for a period. Thus, if it were possible to have the eggs fertilized and laid at a uniform rate during the collection period, an average age could be expressed. Two precautions were taken to obtain this condition: (1) No collection of eggs was used unless the flies from which they were obtained had laid actively during a two-hour period preceding the collection period; (2) no collection of eggs was used unless the flies laid actively during the collection period (3 or 4 eggs per hour per female fly). As will be shown later, fairly uniform ages of material were obtained. The average time of fertilization of eggs in a sample was taken, therefore, to be the middle of the collection period.

Each age sample was divided into ten parts so that different amounts of radiation could be given to eggs of each age. Each part, or each small sample, contained between two and three hundred eggs. Since there were ten samples of about 250 eggs each and since six ages were used, around 15,000 eggs were employed for each experiment. All samples, except one of each age (control), were placed in a shallow tray[1] and were thus ready for treatment.

Irradiation.—The x-ray equipment used was a Victor outfit with a Coolidge water-cooled, tungsten target tube. The tube was operated at 200 K.V. secondary voltage and 33 ma. tube current. The eggs were placed at a distance 35 cm. from the center of the target, and a filter of 0.5 mm. of copper and 2.45 mm. of aluminum was placed directly on top of the tray, approximately 1 cm. above the eggs. Before each experiment measurements of the radiation intensity at the place where the eggs received treatment were made with a drum-head ionization chamber. The intensity was 234 r per minute, any deviation from day to day for the above setting being adjusted by changing the tube current. A lead plate shielded the eggs from the rays while the voltage was being built up. Doses were measured by accurate timing from the moment the lead plate was removed. The different exposures were given by stopping the machine at intervals and removing the samples in proper order.

[1]Made by gluing thin celluloid to a wooden embroidery hoop.

TABLE 1

Age of Eggs*	Exp. No.	Percentage Survival													
Min. Exposure		0	½	1	1½	2	2½	3	3½	4	4½	5	6	7	8	9
5-7 hrs.	I	97.4						97.3		61.6		20.0	8.9	8.9	6.4	
	II	90.5						93.2		73.6		36.3	20.6	11.7	13.7	12.1
	III	93.5				93.6		92.2		68.0		14.6	6.2	12.4	9.2	3.6
4-6 hrs.	I	96.0				99.1		88.8		54.6		5.8	6.8	4.2		4.3
	II	94.0		90.2		94.6		89.3		50.4		8.9	6.0	5.7		6.7
	III	95.4		94.6		92.9		65.9		31.0		13.5	8.4	3.3	2.4	4.3
3-5 hrs.	I	97.0		94.3		93.9		88.2		60.9		45.3	30.4	14.6	3.8	0.5
	II	93.8		95.2		95.1		77.4		43.9		5.7	1.8	4.1	2.2	2.3
	III	96.8		95.8		94.6		76.2		57.3		48.9	30.8	13.4	3.7	1.6
2-4 hrs.	I	97.3		90.3		78.2		63.7		55.8		54.2	39.7	19.3	10.2	6.3
	II	95.5		83.6		76.3		75.7		61.8		48.9	36.0	20.5	6.0	2.4
	III	96.1		72.9		54.3		46.8		46.4		38.9	29.6	16.3	4.0	1.0
1½-3½ hrs.	I															
	II															
	III	94.2		52.2		26.2		12.9		11.6		10.3	10.3	10.3	5.3	9.4
1-3 hrs.	I	96.0	80.6	51.0	25.2	12.4	11.3		13.0		8.0					
	II	91.2	73.3	44.4	20.9	23.0	13.5	16.8	9.6	13.7	11.2					
	III	93.3	76.0	25.1	18.6	10.9	14.9		9.5	7.8	7.3					
0-2 hrs.	I	95.3	85.1	72.7	31.6	20.8	14.2	5.8	2.5	1.9	2.9					
	II	94.4	81.4	49.7	29.7	16.2	9.4	7.6	4.7	4.5	5.2					
	III	97.0	80.2	64.6	38.0	15.6	7.0	3.4								

*From fertilization.

Criterion of Effect.—After irradiation all samples, including the controls, were put away in moist chambers and kept at room temperature, from 21 to 25° C. In from 20 to 30 hours the eggs began to hatch, the larvæ breaking through and crawling away from the egg cases. Those eggs which received sufficient radiation did not hatch. Hatching as an end-point provided a definite criterion of effect, and the relative numbers of hatched and unhatched eggs gave an index of the effect produced by the radiation.

RESULTS

After performing a number of exploratory experiments in order to find the range of sensitivity at different ages, three complete experiments were carried out, the data for which are shown in Table I. Upon examination of the data, it becomes apparent that the younger eggs are in general more sensitive and that there are some fluctuating changes. The results for the different experiments have been plotted graphically in Figures 1, 2, and 3, respectively, survival curves being drawn in each case for eggs of different ages.[2] In order to interpret the results more easily summary curves were plotted where possible. Figure 4 gives such curves for eggs of the ages 0-2, 1-3, 4-6, and 5-7 hours. Between the ages of from 2 to 4 and 3 to 5 hours some rather sharp changes in radiosensitivity occur. Accordingly, curves for eggs from 2 to 4 and from 3 to 5 hours of age show considerable variation among themselves, although their general trend in each case is the same. They have been plotted together for the respective ages (Figs. 5 and 6).

[2]It will be seen from Table I that the fertility of the controls in each case ranged from 92 to 98 per cent. The general average for each experiment was 96.5, 93.2, and 95.4 per cent, respectively. These values were made to read 100 per cent in plotting the curves, and all of the values for the other points were adjusted accordingly.

By referring to the various graphs the susceptibility changes may be followed qualitatively. For the youngest eggs (0-2 hours old) an asymmetrical sigmoid type of curve is obtained when percentage survival is plotted against dosage (see Fig. 4). One hour later a similar curve is obtained, the main portion of which lies to the left of the first. This indicates that at this stage the eggs were more susceptible to the radiation than they were one hour previous. Since there must be a few older eggs in each sample which are like those just older and therefore much more resistant, the whole curve is higher than it otherwise would be, the lower part being raised more than the upper by this factor. This will account for the second curve's crossing the first at the lower end.

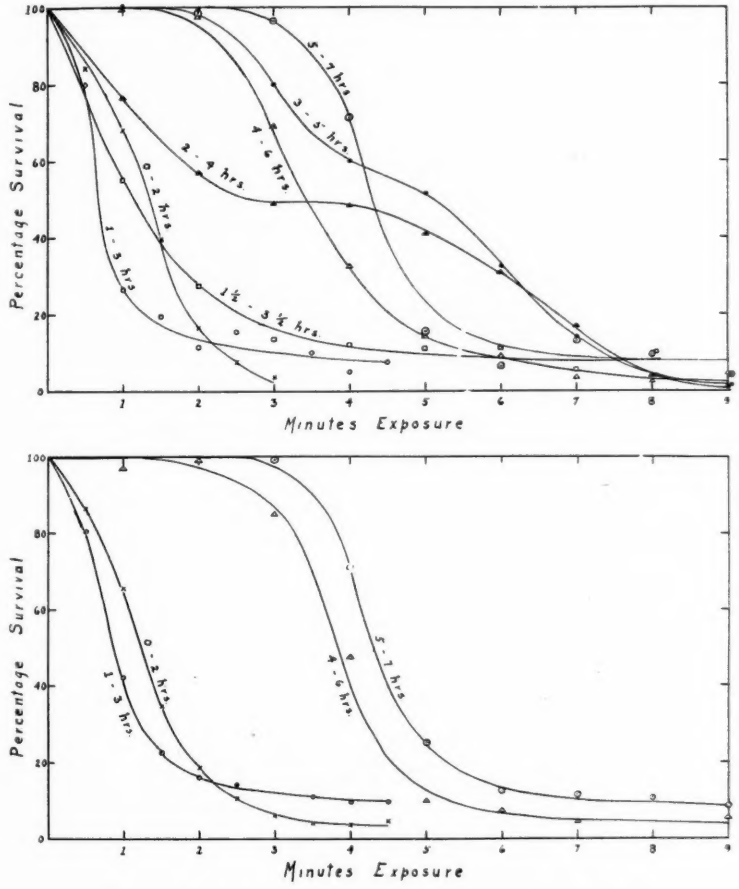


Fig. 3. Survival curves for eggs of different ages. Exp. III.

Fig. 4. Composite survival curves for Exp. I, II, and III.

Eggs from 2 to 4 hours old were much more resistant than those slightly younger. In order for this condition to exist, it is obvious that an abrupt increase in resistance must have taken place between the ages of from 1 to 3 and 2 to 4 hours. Figure 5 shows the curves for the 2 to 4 hour mate-

rial plotted together. It is significant that some of the eggs of this age are more resistant than any of those just younger or just older. This shows that the sudden increase in resistance is followed by a decrease. younger. Accordingly, the ones slightly older and younger, though different in age, would have the same radiosensitivity. Such a condition would affect the curves by producing a level part somewhere in the mid-

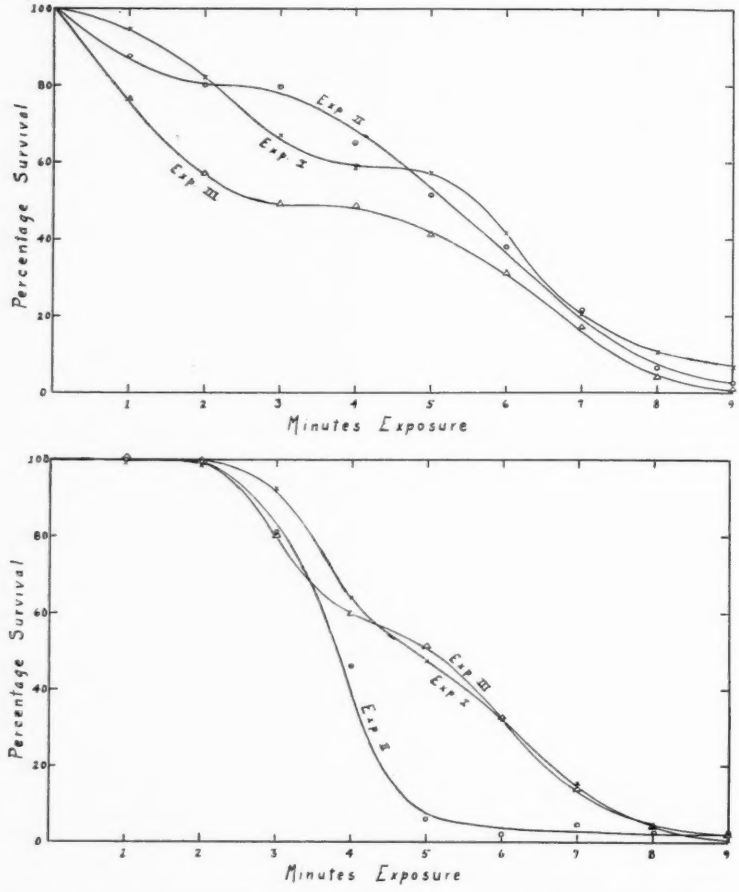


Fig. 5. Survival curves for eggs from 2 to 4 hours of age, Exp. I, II, and III.

Fig. 6. Survival curves for eggs from 3 to 5 hours of age, Exp. I, II, and III.

With changes of this sort going on at this stage, it is not surprising that the curves in Figure 5 vary. Despite the variation shown, however, they are generally similar in shape and have particular points of resemblance. For instance, it has just been pointed out that some of the eggs are more resistant than those somewhat older or dle region. As seen, each curve contains a short level part.

Similar correlations can be made for 3-to-5-hour samples. The curve in Figure 6, marked by small triangles, is interesting (see Fig. 3, the group of curves from which it was taken). The lower portion follows the course of the curve for eggs from 2 to

4 hours old, while the upper portion follows the course of the curve for eggs from 4 to 6 hours old. Half of the eggs, therefore, appear to be like those of the older group, while the other half appear similar to those of the younger group. This indicates that the change from the condition at 2 to 4 hours to that at 4 to 6 hours takes place very rapidly. The curve marked with circles is entirely like that for the 4-to-6-hour-old material. The curves for eggs from 4 to 6 and 5 to 7 hours old bear a close resemblance. The eggs of these groups are not only less resistant than some of those from 2 to 4 and 3 to 5 hours old, but show a more uniform susceptibility, as is evidenced by the vertical portion of the curves. Practically all are killed when a certain threshold of radiation is reached.

Thus it is seen that the changes in resistance at the various stages can be followed, but the process is tedious. It is desirable, therefore, to obtain a sensitivity-time curve which will show the changes. For this, it is necessary to plot the amount of radiation required to produce a certain effect as a function of age. Any percentage mortality may be used for the effect to be considered. Because it gives the susceptibility of the greatest number of eggs, 50 per cent killing was selected. A set of values has been read from the curves in Figures 4, 5, and 6 and plotted as shown (Curve *B*, Fig. 7). The curve shows in a general way what was described qualitatively above; however, the following question may be asked: Will the curve vary, depending upon the effect chosen? To answer this—curves for 10 and 90 per cent

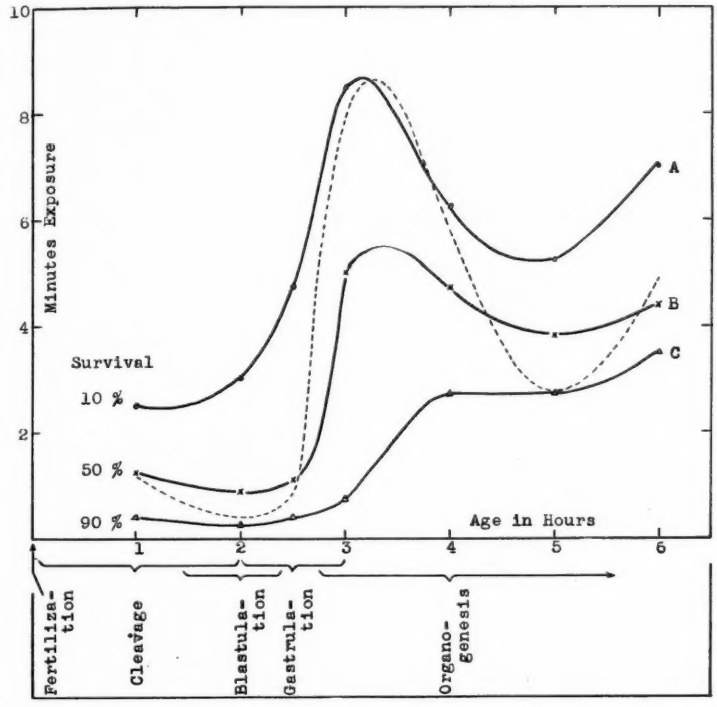


Fig. 7. Sensitivity-time curves, showing changes in radiosensitivity for different degrees of irradiation effect.

killing (90 and 10 per cent survival, respectively) were plotted. Curves *A* and *C* (Fig. 7) were thus obtained. Curve *A* (10 per cent survival) shows the radiosensitivity of the more resistant eggs, while Curve *C* (90 per cent survival) shows it for the more sensitive eggs. Since the values for the sensitivity-time curves were taken from survival curves for eggs which varied as much as 2 hours at least in age and since it has been shown that the radiosensitivity varies markedly with age, it is clear that the eggs must have undergone changes in susceptibility, indicated roughly by the extremes shown in Curves *A* and *C*. The dotted line curve joins the extremes.

Whether the changes in susceptibility are as marked as indicated by the dotted line curve makes little difference; however, for the present consideration, Curves *A*, *B*, and *C* are all similar in shape and each shows changes amounting to several hundred per cent, which answers the point in question. The amount indicated by any curve could be reduced by half and still show that important changes in radiosensitivity occur during early development.

CORRELATION OF CHANGES IN RADIOSENSITIVITY WITH STAGES IN DEVELOPMENT

In order to correlate the stages in development with the various degrees of radiosensitivity observed, it was necessary to determine what stage the majority of eggs were in at each of the various ages. For this purpose, around 200 untreated eggs of each age were fixed and sectioned. These were examined with two points in mind, in addition to that of associating the age and stage in development: (1) To ascertain what the nature of the developmental activity was at the different stages, and (2) to determine the distribution of stages in each sample, thus checking the uniformity of age.

Early Development.—Plates I and II show photomicrographs of *Drosophila* eggs at various stages in development. Typical of insect eggs in general, the *Drosophila* egg consists of a cell wall or vitelline membrane, within which are the single large nucleus and many nutritive granules suspended in a semi-fluid protoplasm (Plate I, 1). Surrounding the egg is an egg case, or chorion, which is secreted by the ovarian cells of the adult female fly. As the eggs pass through the vagina they are capable of being fertilized by spermatozoa which have been stored by the male in the seminal receptacle. Sperm enters the egg through the micropyle of the chorion, and a sperm-nucleus unites with the egg-nucleus to form the segmentation-nucleus.

The segmentation-nucleus, lying free among the yolk granules, is surrounded by a small volume of oöplasm and gives rise to other nuclei by mitosis. Nuclei only are involved in the early cleavages, cell membranes not being present. At the 256-cell-stage (eighth cleavage) (Huettner, 3) the nuclei begin to migrate to the periphery where cell membranes are formed around them and where they arrange themselves into a single cellular layer to form the blastoderm (Plate I, 2-4). At this stage the germ cells are distinguishable by their larger size, located in the posterior polar region. The blastoderm becomes thickened by continued mitosis and growth (Plates I and II, 5-15), and presently gastrulation begins by invagination (Plate II, 16). From this point organogenesis proceeds by differentiation and structural expression.

Age Distribution in Samples.—The distribution of developmental stages in the different age samples was determined by preparing a chart. Easily recognizable stages were selected and the number appearing in each age sample was counted (see Table II). The stages selected were as follows: (1) A uniform distribution of yolk material throughout the interior of the egg, this stage including all prior to migration of the nuclei to the periphery (Plate I, 1); (2) a

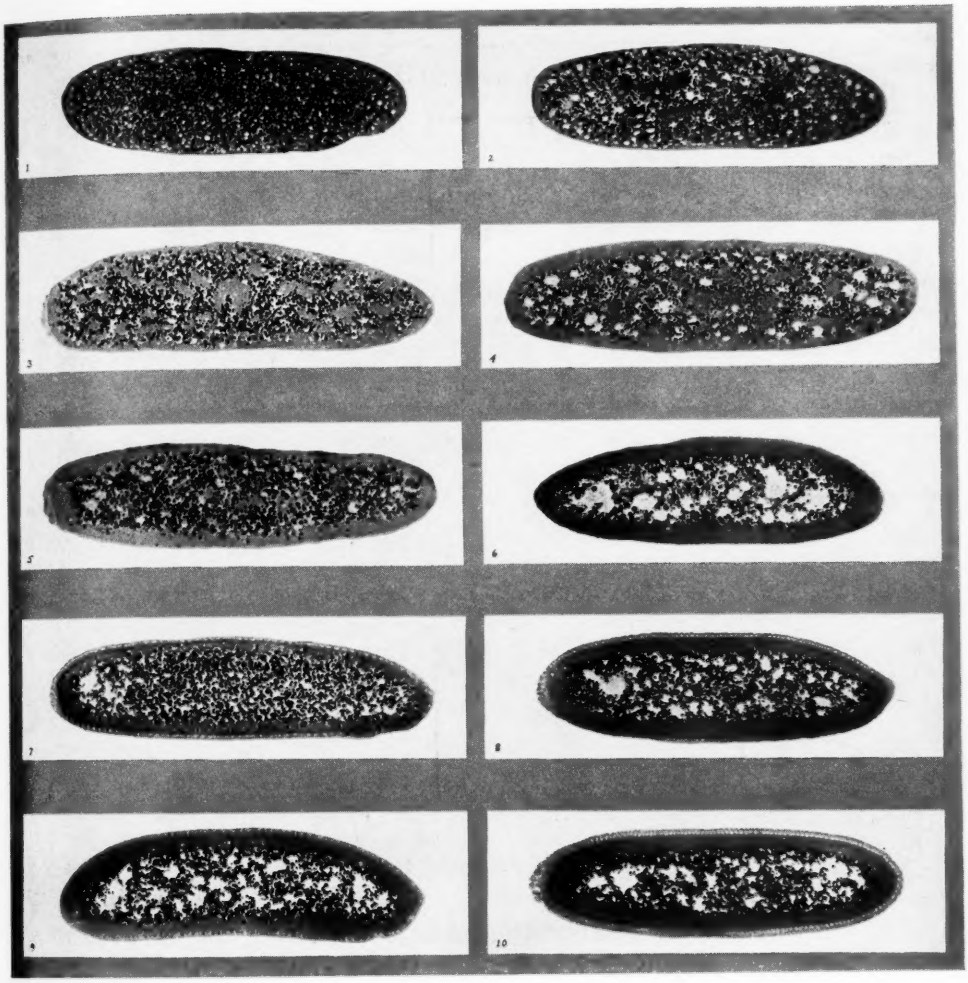


Plate I—Photomicrographs of *Drosophila* embryos in various stages of development (× 75), arranged to show developmental stages only.

shallow peripheral area devoid of yolk granules (Plate I, 2-6); (3) a thin but definite blastoderm (Plates I and II, 7-14); (4) a thickened blastoderm but no gastrulation (Plate II, 15), and (5) gastrulation and beyond (Plate II, 16-20).

With the aid of Table II the following information may be derived: (1) In each sample there were a few eggs which did not undergo development; (2) in each sample there were a few which were in advanced stages of development, these probably being eggs which had been retained in the female fly for a period after fertilization; (3) certain stages were longer than others with respect to time (made evident by the fact that fewer organisms of a given age were in a certain stage than in a stage just younger or just older: Stage 2 of eggs 0:20-2:20 hours old is an example of this), and

TABLE II

Age of Eggs in Hours	Developmental Stages*										Total No. of Eggs Examined
	1		2		3		4		5		
	No.	%	No.	%	No.	%	No.	%	No.	%	
0 - 2	105	97.3	1	0.9					2	1.8	108
0:20-2:20	98	80.3	7	5.7	15	12.3			2	1.6	122
1 - 3	63	34.0	18	9.7	78	42.2	5	2.7	21	11.4	185
2 - 4	5	4.2	4	3.3	51	43.0	12	10.2	46	39.0	118
3 - 5	2	3.9			10	19.6	7	13.7	32	62.7	51
4 - 6	6	4.5							126	95.2	132
5 - 7	2	1.5							133	98.5	135

*See text.

(4) the point of most importance here—the majority of the eggs in each age sample tend to fall into one stage or closely associated stages, thus making it certain that most of the eggs in each sample were approximately of the same age.

Unfortunately, the chart does not make clear whether the eggs were fertilized at a uniform rate during the entire collecting period, or whether the majority were fertilized during the first or last part of the period. Because of the probability that such variation may often take place, the middle of the collection period, taken as the average time of fertilization for a collection of eggs, must be considered as an approximation.

Since the stages in development for the different ages are shown in Table II and since the changes in radiosensitivity and age have been correlated above, the correlation of radiosensitivity and stage in development are obtained by properly locating the stages in development on the time axis of the sensitivity-time curve. This has been done in Figure 7. The sensitivity-time curve, as far as it has been determined, shows two important parts with respect to radiosensitivity: first, the comparatively flat portion at the beginning, which shows a low resistance, and second, the vertical portion, which shows a sudden increase and peak in resistance.

DISCUSSION

Having found that the susceptibility of *Drosophila* eggs to x-rays changes markedly during early development, it is clear that such changes should be taken into consideration when this material is used in irradiation experiments. Packard (4) in numerous reports and particularly in a recent communication, has shown that *Drosophila* eggs are remarkably constant in their response to radiation, pointing out that 180 r invariably kill close to 50 per cent of the eggs in a sample.

It is difficult at first to reconcile Packard's results with those presented here. After careful consideration of his experimental procedure, however, we find that he is very cautious about keeping the age of material precisely the same for all experiments. He collects eggs from actively laying flies during a two-hour period, begins the exposure

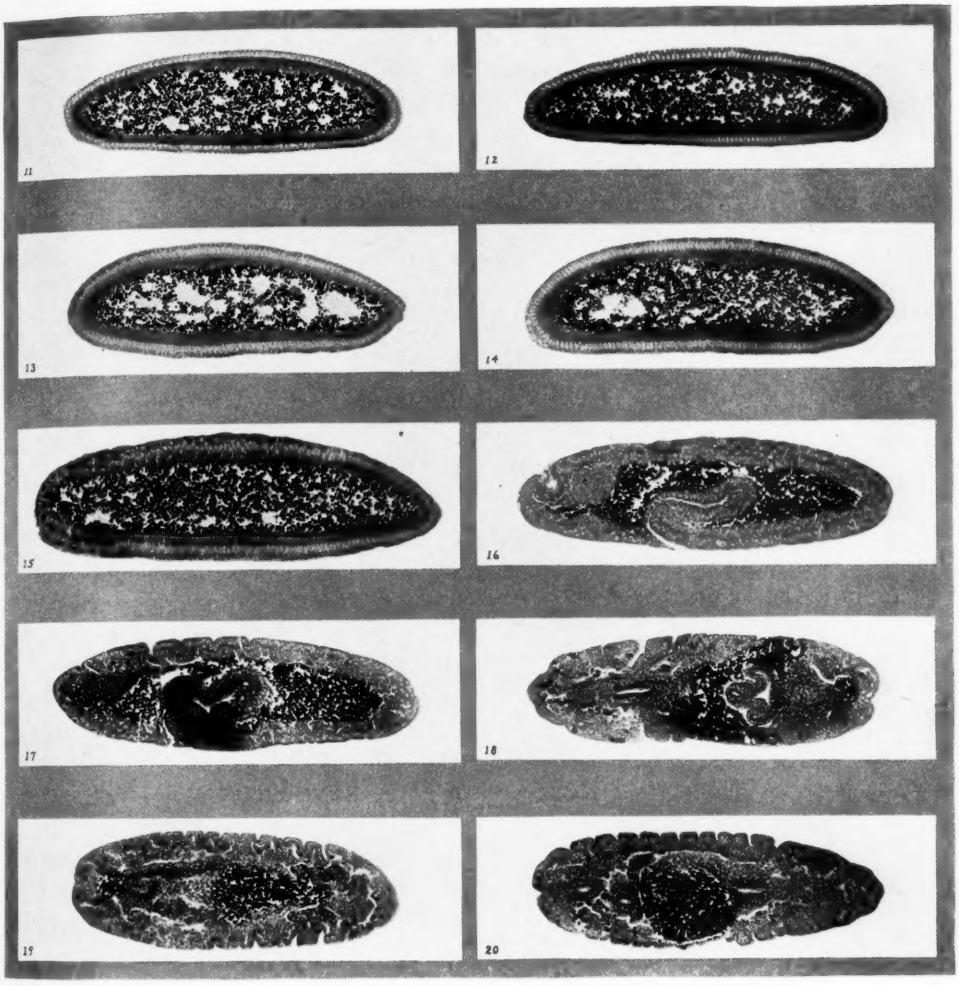


Plate II—Continuation of Plate I. (See text.)

one hour after the end of the collection period, and limits the longest exposure to 25 minutes. In the recent article he states that it is important that these intervals should not vary. Quoting from Packard: "At the time of irradiation, that is, three hours after the laying period commences, the eggs are in the most sensitive condition. As they grow older they become more and more resistant to the radiations, so that three hours later they are approximately half as sensitive." By comparing these statements with our results, as shown in Figure 7, they will be found to be in good agreement. The peak in resistance, however, which is reached between three and six hours after the laying period commences, has not been mentioned by Packard. Since the sensitivity-time curve indicates that extensive changes in susceptibility take place at this time and since the age of material used by Packard falls at the beginning of this period, it is plainly evident

why it is necessary to so rigidly control the age factor. That the samples of material used by him contained some of the more resistant eggs is made evident by the shape of his "standard" survival curve. An examination of this shows that, relatively, much more radiation is required to kill the last few eggs in each case.

But, does the precise control of the time relations in experimental procedure fully regulate the age of the material? Since it is age in development rather than age in minutes which designates the susceptibility, it is clear that all factors influencing the rate of development should also be controlled. Temperature, as an example, is particularly important in this respect because the rate of growth and development are dependent on this factor.

In a series of experiments in which we have irradiated two parts of the same collection of eggs at the same time in the same beam of radiation, practically identical results were obtained in nearly all cases. On the other hand, the experiments presented above are good examples of what has been our experience when different samples of eggs were irradiated on different days and an attempt made to keep the conditions of irradiation precisely the same. Take, for instance, the curves marked 1-3 hours in Figures 1, 2, and 3, which are for the same age of material as that used by Packard. The results, though quite consistent for individual experiments, vary for different experiments. In Figure 2 the curve indicates that around 250 r were required to kill 50 per cent of the eggs, while in Figure 3 it shows that somewhat less than 200 r were required to kill the same amount. The relationships of certain curves in each figure indicate reasons for believing that the sets of samples for each experiment, though of the same "clock age" in each case, were not of the same age developmentally. For example, those used for Experiment 2 were all probably a little more advanced in development than those used for Experiment 3, since the curve marked 3-5 hours is entirely like the one just older, while in Figure 3 the main portion of the curve is like the one for eggs just younger. The degree of separation of curves marked 0-2 and 1-3 hours in each case also gives an index of age. This too corroborates the idea that the material used for Experiment 2 was more advanced than that used in Experiment 3. Packard's method is to average the results for several experiments together, thus obtaining a fairer idea of the effects of the rays. This has a tendency to eliminate the inequalities occurring in different experiments, and his work shows well the reproducibility of results which can be obtained when this procedure is followed and when the experiments are carried out in the same way by the same individual. As for experiments performed by different individuals in different laboratories, it seems unlikely that the results can be reliably compared, in view of the fact that the susceptibility changes so rapidly during development and that the rate of development is difficult to control.

It should be clear that our results are not at variance with Packard's. We merely go further in pointing out precautions which must be taken when *Drosophila* eggs are used as test material.

CONCLUSIONS

1. The radiosensitivity of *Drosophila melanogaster* eggs has been found to vary considerably during early development.

2. A correlation of the changes in radiosensitivity with stages in development showed that the eggs become more sensitive during cleavage and blastulation, much more resistant at the time of gastrulation, and more sensitive again following gastrulation, all of this taking place within three hours after the eggs are collected.

Acknowledgments.—The authors wish to express their appreciation to Dr. G. Failla and Mrs. E. H. Quimby for valuable suggestions and helpful criticisms and to Miss D. S. Francis for valuable assistance.

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ATELECTASIS AS A COMPLICATION OF PULMONARY TUBERCULOSIS[1]

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ATELECTASIS as a complication of pulmonary tuberculosis has been recognized only during the past few years. It was first called to our attention in post-operative cases by the roentgenologists and surgeons. In these post-operative cases re-expansion or aeration of the atelectatic lung usually occurs promptly, especially if the patient is rolled backward and forward after the method described by Sante (1). In chronic pulmonary infections, especially tuberculosis, the tendency of atelectasis is to remain permanent, with the consequent formation of a fibrotic lung. Packard (2), in 1928, was one of the first to describe atelectasis in pulmonary tuberculosis, remarking on the mildness of the symptoms produced, its permanency, and the beneficial effect it had on the course of the disease. Hablitson (3) the same year described a case of massive collapse of the left lower lobe in which artificial pneumothorax was employed with improvement. Jacoboeus and Westermark (4) reported four cases in tuberculosis, and showed the value of artificial pneumothorax in the treatment of these cases. Hennell (5) described it as a factor in the production of fibroid phthisis. Korol (6) reports six cases occurring in tuberculosis. Glenn (7) described a number of cases and showed the value of artificial pneumothorax in the treatment. The writer (8) has reported eight cases and also undertaken to show the value of some form of artificial compression.

As the complication is rarely fatal, a great deal cannot be definitely said as to what is the exact causative factor in the production of atelectasis in tuberculosis. Undoubtedly the chief causes of bronchial obstruction are aspiration of a caseous plug, hemorrhage with clot formation, plugging of a bronchus with thick tenacious sputum, pressure from an enlarged lymph node, and possibly contraction of a cicatrix.

Lloyd (9) studied a number of cases by means of the bronchoscope, but was unable to find any obstruction in the larger bronchi, and believed that it was in the smaller bronchi beyond the vision of the bronchoscope. Glenn remarked that in all the cases that came under his observation, one or more cavities were present in the upper lobe of the involved side. This was also true in the cases seen by us. In our series the left side was involved more than the right.

The pathology of this complication has been discussed rather extensively. As it does not prove fatal at the time, we must rely on roentgenographic studies and the use of artificial pneumothorax to demonstrate the nature of this condition in tuberculous cases. The pathology is essentially a bronchial or bronchiole obstruction, with absorption of the air and a consequent atelectasis or collapse of the air cells in that portion of the lung beyond the obstruction. As a result, the lung volume is reduced to a great

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30-Dec. 4, 1931.

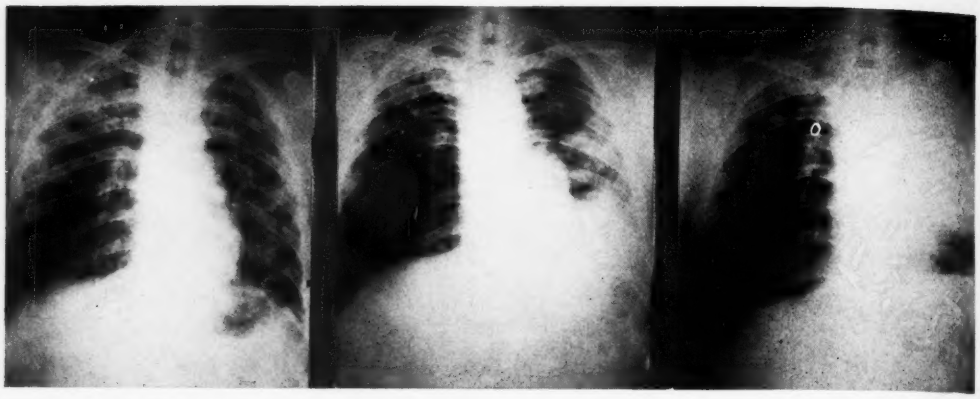

Fig. 1. Case 1, Dec. 11, 1929. Multiple large cavities throughout the left lung; some infiltration in the right apex.

Fig. 2. Case 1, July 18, 1930. Results of phrenic exeresis on the left; also partial atelectasis in lower lobe. Cavities still present.

Fig. 3. Case 1, Jan. 20, 1931. Complete atelectasis of left lung, with closure of cavities. Note high position of diaphragm.

extent, and a marked negative pressure produced, increasing the already negative pressure in the pleural cavity.

Because of this marked negative pressure, the trachea, mediastinum, heart, and diaphragm are forced toward the affected lung in an effort to equalize the pressure. In tuberculosis, as has been stated, atelectasis tends to remain permanent, and consequently the lung becomes fibrotic. The contraction of this scar tissue further increases the negative pressure, and is undoubtedly a factor in helping to produce deformity of the chest wall, and even of the spine. In only one of our cases did re-expansion of the lung occur, and this took place in about two weeks, with a fatal result.

Glenn considers the development in massive cases to be slow and gradual, as the obstruction is only partial at first. In those under our care it appeared to develop suddenly. In some there had apparently been at first a partial atelectasis, or one of lesser extent, which persisted for some time without change, whereupon, suddenly, a massive atelectasis would occur. It appears to us that atelectasis may develop successively and suddenly, rather than progressively and slowly.

The tendency of a massive atelectasis is to collapse cavities as well as lung tissue, and in many cases, therefore, it produces a beneficial result on the course of the disease. This apparently does not hold true in cases in which the cavities have a thick wall or are situated in an apex. As a rule, apical cavities are held open by pleural adhesions. Under these conditions cavities tend to enlarge, due to the increased negative pressure, and the disease is not controlled until they are closed by some artificial means. In addition, hemorrhage may occur in these cavities; and also, as in one of our cases previously reported, a spontaneous pneumothorax may develop. The effect of atelectasis on the opposite lung is to produce emphysema, which may, in turn, have a detrimental effect on disease there present.

One condition that may be mistaken for an atelectasis, from the roentgenographic standpoint, occurs in artificial pneumothorax cases in which the lung has become fibrotic and fails to re-expand when the compression is discontinued. Here the air in the pleural cavity is absorbed, with a marked negative pressure resulting, and a consequent phenomenon is produced, identical with atelectasis.

Packard, as well as others, has found the symptoms produced by a massive atelectasis relatively mild. In most of the cases seen by us the regular history and even close questioning failed to elicit the time of its occurrence. In the cases that developed under our direct supervision, the patients complained of slight pain over the involved lung, and moderate shortness of breath. Some cyanosis and elevation of temperature occurred. In a few, the onset was stormy and at first mistaken for pneumonia.

Fig. 4. Case 2, Nov. 13, 1931. Massive atelectasis of left lung, with resultant fibrosis and marked displacement of heart, trachea, and right pulmonary artery. Scoliosis of spine to right. Disease arrested.

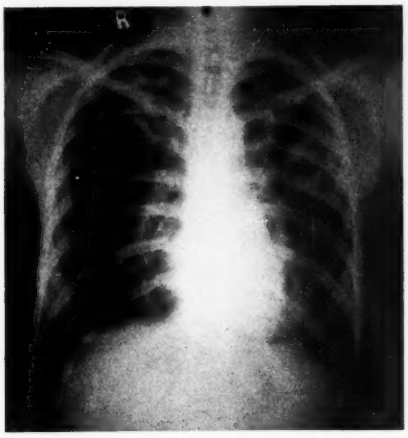

Fig. 5. Case 3, Aug. 25, 1930. Cavity in left apex, and scattered infiltration.

Physical examination often reveals the true condition in cases in which the atelectasis has been rather extensive. The findings are mainly diminished expansion over the involved side, with cardiac displacement toward the atelectatic lung. The percussion note is dull, and the breath sounds and râles usually disappear. These signs vary, however, at times.

The roentgenogram is the best method of detecting atelectasis. Here, as has been described by others, there is a marked opacity over the involved lobe or lobes; the heart, mediastinum, and trachea are displaced toward the atelectatic lung, and the diaphragm is elevated. There is also usually narrowing of the interspaces, and often the opposite lung may be displaced into the field of the atelectatic lung. In some cases a scoliosis of the spine may result from contraction of the interspaces and a consequent bowing of the spine toward the opposite direction. This may be corrected by pneumothorax. When the atelectasis is of lesser degree, the roentgenogram or fluoroscope is probably the only means of detecting it.

The treatment of atelectasis developing in pulmonary tuberculosis depends upon the closure of cavities in the involved lung. In the cases in which the desired effect is obtained by this complication alone, interference in any way is certainly not indicated. In a few of our cases, and in cases reported by Packard and Hennell, decidedly beneficial effects were obtained. The marked displacement of the heart, mediastinum, and diaphragm apparently causes no discomfort to the patient, and the disease may become entirely arrested.

In cases in which cavities do not close the tendency is for them to enlarge due to the increase of negative pressure; consequently

there is a progression of the disease. In these instances pneumothorax, or some form of artificial compression, is the treatment of choice. The intrapleural pressure is greatly reduced, and many times the fluid

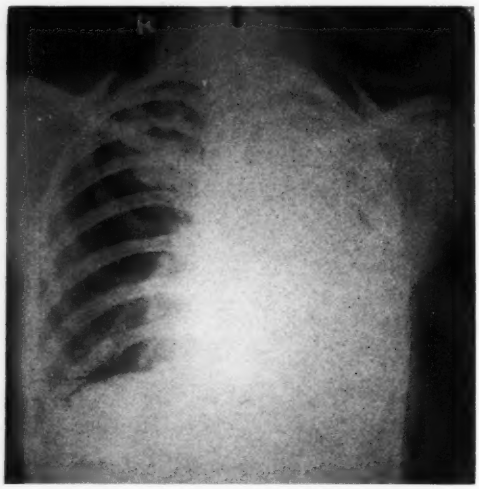

Fig. 6. Case 3, May 14, 1931. Massive atelectasis of left lung.

in the manometer is sucked over the top so that the exact reading cannot be obtained. In nearly all the cases previously reported by us, pneumothorax was attempted, and excellent results obtained. The heart, mediastinum, trachea, and diaphragm were returned to their normal positions; the intrapleural pressure increased to or approximately normal, and clinical improvement followed. At times, pneumolysis is necessary for complete closure of cavities. In cases in which an adherent pleura is present and pneumothorax cannot be instituted we have employed phrenic exeresis and thoracoplasty with most beneficial results.

In two of our cases in which pneumothorax was instituted, it was discontinued, but then only because of the desire of the patients. A phrenic exeresis was done, however, before discontinuance. Re-expansion of the lung did not occur. Fluid usually develops when the air in the pleural cavity is absorbed in these cases, and with the absorption of fluid, the displacement of mediastinum, heart, diaphragm, and trachea reoccurs.

CASE REPORTS

Case 1. A. M.,[2] male, aged 36. Onset of tuberculosis in December, 1926. Sputum positive. Under rest treatment condition became gradually worse. Weight fell from 180 to 121 pounds. Patient ran an afternoon temperature and raised about four ounces of sputum per day. Physical examination on Dec. 8, 1929, showed: *Right chest,* resonance fair; medium râles in upper portion; *left chest,* medium coarse râles, base up; increased whispered voice in upper.

Roentgenogram (Fig. 1), Dec. 11, 1929, showed a fibrocaseous infiltration in the right upper, with a questionable cavity. The left lung showed large cavities scattered from apex to base. Under rest, patient showed no improvement, so a left phrenic exeresis was done April 24, 1930, resulting in moderate rise of the diaphragm. Roentgenogram (Fig. 2) taken July 18, 1930, showed the left diaphragm high; cavities on the left somewhat smaller, but still open; some opacity in left base, possibly an area of atelectasis.

Following this there was a slow gain in weight. In October, 1930, weight was 140 pounds, a gain of about 20 pounds. Patient was on continuous bed rest, and under daily observation there was no material change in the lung. On Oct. 15, 1930, he had a moderate hemorrhage. At this time was under treatment in Los Angeles. Following the hemorrhage, his temperature was elevated and he stated that he had some pain in the left lung. However, he soon began to improve and gain weight.

Chest examination following the hemorrhage showed dullness over entire left lung, with marked increase in whispered voice and bronchial type of breathing. There were a few râles over the left lung and in the right apex. Roentgenogram (Fig. 3) taken Jan. 20, 1931,

[2]Case previously reported.

showed the pathology in the right apex decreased considerably, no cavity being visible. The left lung was opaque and the diaphragm extremely high. The heart was displaced to the left. The cavities had now disappeared. Under further rest treatment the patient continued to gain in weight, and sputum was reduced. At present the weight is 181, a gain of 41 pounds since the atelectasis. Patient is now able to be up and about, and hopes to return to work shortly. Undoubtedly the massive atelectasis developed at the time of the hemorrhage, in October, 1930. There probably was a partial atelectasis, however, as seen in the last roentgenogram prior to the hemorrhage.

This case shows well the beneficial effects of atelectasis which, in this instance, resulted in closure of cavities and an apparent arrest of the disease.

Case 2. A. R.,[3] male, aged 45. Developed tuberculosis in 1914. Was quite ill in 1917, and was told he had pneumonia. Rested 27 months and improved steadily. In 1919 he was able to return to work and has felt well up to the present time, except for an occasional pain in the left chest.

Examination May 28, 1930, showed retraction of left chest, with diminished expansion. The apex beat was displaced to the left. The left lung was dull and the breath sounds absent in base and amphoric in apex. There were a few dry crackles posteriorly on the left. Marked spinal curvature to right. Weight 150 (normal 150). Sputum negative.

Roentgenogram (Fig. 4) dated Nov. 13, 1931, showed a massive atelectasis of the left lung, with a marked displacement of the heart and trachea. Diaphragm was high, but not well visualized. There was a decided scoliosis of the spine to the right. This latter was due to the contraction of the fibrotic left lung, with narrowing of the interspaces and a resultant bowing of the spine.

In this case the atelectasis undoubtedly occurred in 1917 at the time he was told he had pneumonia. Marked clinical improvement with an arrest of the disease is also demonstrated in this case.

[3]Reported by courtesy of F. G. Holmes, M.D.

Case 3. C. J., female, aged 42. Developed tuberculosis in Summer of 1930. Had a severe cough, with weakness and loss of weight. Sputum was positive in August, 1930. Rested at home and showed improvement, gaining weight, and temperature remained normal.

Roentgenogram (Fig. 5), taken Aug. 25, 1930, showed heart, trachea, and diaphragm in normal positions, with some infiltration in the right apex. In the left there was scattered infiltration throughout, with a small cavity behind the second interspace.

Examination in December, 1930, showed a few medium râles in the right apex. On the left there was slight impairment of resonance, with medium coarse râles in upper part of chest. Breath sounds were slightly diminished.

Roentgenogram taken Dec. 12, 1930, showed some fibrous infiltration in the right apex. The left lung field was slightly narrowed and hazy. In the upper part of the left lung there was a caseo-ulcerative infiltration. Scattered throughout the lower portion of the left lung were numerous small areas of caseous pneumonia. The base of the heart was displaced slightly to the left. The left diaphragm was depressed. It is possible that there were areas of atelectasis in the upper part of the left lung at this time, along with the other pathology. The cardiac displacement and slight haziness would indicate this.

Patient showed only slight improvement and on April 26, 1931, developed pain in the left chest, and high temperature. Her cough increased and she noticed some shortness of breath, and mild cyanosis of nails. Examination of the chest on April 29, 1931, revealed dullness over the left chest, with diminished breath sounds in the base. Whispered pectoriloquy was present in the apex. Position of heart is not recorded. The elevation of temperature continued for about two weeks, and the cough improved somewhat. Patient began to feel better, but ran an afternoon temperature.

Roentgenogram (Fig. 6) taken May 14, 1931, showed a massive atelectasis of the left lung, with some areas in the apex suggesting cavities. The heart was displaced to the left and the diaphragm was high. The right apex

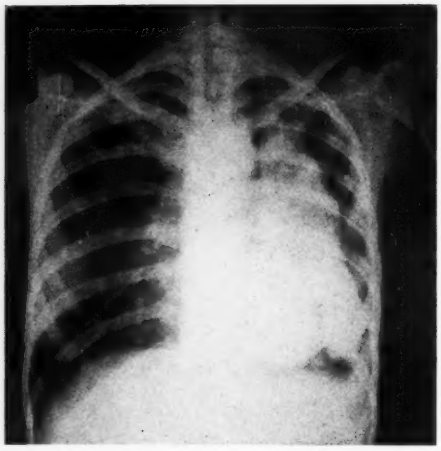

Fig. 7. Case 3, May 17, 1931. Effect of pneumothorax, with a return of mediastinum, diaphragm, etc., to normal position. Cavity held open by apical adhesions.

appeared improved. Physical examination revealed condition about the same as on April 29.

On May 15, 1931, artificial pneumothorax was instituted. The initial reading could not be obtained because of the marked negative pressure. After 350 c.c. of air were given, the resultant pressure was —9 —5. Since then, the patient has continued under pneumothorax and has improved considerably, but she still has slight temperature, some cough, and the sputum remains positive.

Roentgenogram (Fig. 7) taken May 17, 1931, shows a fair compression of the left lung. Cavity in apex of compressed lung, however, is held open by adhesions. The heart has returned to its normal position, and the diaphragm is down. There is some fluid present in the pleural space; a left phrenic exeresis was done Aug. 22, 1931, with only a fair rise in the diaphragm. At the present time the cavity is still open and will probably require pneumolysis to effect its closure. Patient has periodic upsets of temperature and sputum is positive.

Case 4. A. O.,[4] female, aged 45. Developed tuberculosis in May, 1929. Lost about 25 pounds and had intermittent attacks of pleurisy in the right lung. In July, 1930, she had a small hemorrhage and since then has been running an afternoon temperature.

Examination Nov. 4, 1930, showed: In right chest diminished expansion and medium râles, base up. Percussion note was fairly resonant and no cavity signs were made out. In the anterior mid-portion of the left lung there were a few medium râles. Weight, 106 (normal, 145).

Roentgenogram (Fig. 8) taken Nov. 5, 1930, showed scattered fibrous infiltration in right upper, with a suspicious area of cavitation. The right diaphragm was slightly elevated, and there was an opaque area in the base near the heart, the heart being slightly displaced to the right. There was some diffuse caseous infiltration in the mid-portion of the left lung. Under the fluoroscope there was slight restriction of motion of the right diaphragm. The opaque area in the right base was first thought to be a localized tuberculous pneumonia. However, this remained stationary, and in all probability was an atelectatic area. Under rest, condition improved somewhat, and patient gained 20 pounds in weight, but she continued running a daily temperature.

A roentgenogram taken Jan. 12, 1931, now showed a definite cavity in the right apex, also a slight increase in pathology in the left lung. Monthly physical and fluoroscopic examinations were made, and patient was seen daily. On Feb. 18, 1931, she complained of some pain in the right chest, with an increase in cough. Temperature rose from 99.5 to 101.0 and pulse from 95 to 115. She did not complain of shortness of breath or palpitation, but slight cyanosis was present. Chest examination now revealed dullness over the right lung, with absence of breath sounds in the lower part. The breath sounds were amphoric in character in the apex. The râles had disappeared, and the heart beat could be felt to the right of the sternum. Fluoroscopic examination on February 18 showed an atelectasis on the right side.

Roentgenogram (Fig. 9, over-exposed) taken Feb. 20, 1931, showed trachea and heart markedly displaced to the right and the right

[4]Part of this case previously reported.

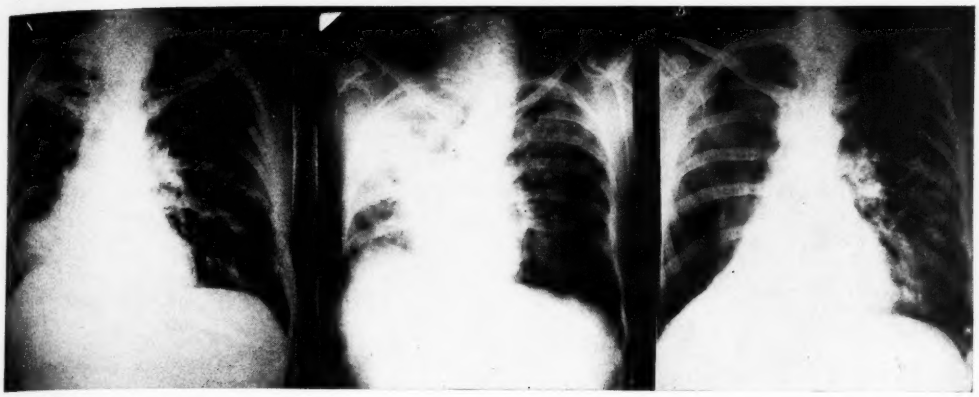

Fig. 8. Case 4, Nov. 5, 1930. Cavity in right apex, with atelectatic area in base. Diaphragm shows slight elevation.

Fig. 9. Case 4, Feb. 20, 1931. Atelectasis of right upper lobe.

Fig. 10. Case 4, March 28, 1931. Shows effect of artificial pneumothorax, with return of viscera to normal position. Cavity still open in right apex.

diaphragm high. The cavity in the right apex was now well distinguished. The atelectasis was confined chiefly to the upper lobe. The patient did not complain of much discomfort.

Artificial pneumothorax was instituted on Feb. 20, 1931. The initial manometer reading could not be obtained as the fluid was sucked over the top. Patient was given 375 c.c. of air, the resultant reading being —6 —2. Under the fluoroscope the heart was seen in its normal position and the diaphragm was depressed. Patient improved somewhat under pneumothorax but still ran a temperature, and sputum was positive.

Roentgenogram (Fig. 10) taken March 28, 1931, showed a partial pneumothorax, the cavity being held open by adhesions. Heart and diaphragm were seen in normal position. A right phrenic exeresis was done on May 25, 1931, with the hope that the cavity would close. Roentgenogram (Fig. 11) taken on May 16, 1931, showed considerable elevation of the diaphragm, cavity, however, being still present. Patient returned to her home on May 25, 1931, but was not able to continue pneumothorax. She soon developed fluid with the absorption of the air, and for a while had a stormy time. She returned for examination on Nov. 22, 1931, when her condition was poor, the weight having dropped to 98 pounds.

Roentgenogram (Fig. 12) taken Nov. 22, 1931, showed a homogeneous opacity over the right lung, with the exception of the apex, where there was a large cavity. The heart and trachea were displaced to the right. The right diaphragm could not be seen. There was a slight curvature of the spine to the right. The interspaces were narrowed slightly. There was a possibility of fluid still being present in the right pleural space. (Tapping will be attempted.) The pathology of the left chest has resolved.

This case is extremely interesting in that it shows successive atelectasis developing, with a return to normal position of the heart, diaphragm, etc., with the use of pneumothorax. In addition, it demonstrates the lack of expansion of an atelectatic lung following the use of artificial pneumothorax, and also it plainly shows enlargement of apical cavities in these cases. Thoracoplasty or a paraffin pack will undoubtedly have to be resorted to in this case when patient's condition will permit.

Case 5. P. D., female, aged 26. First seen Aug. 13, 1929. First noticed symptoms in May, 1929, following a cold. Had severe cough, with some pain in right lung. Sputum positive. Has been resting 24 hours daily since.

Examination on Aug. 13, 1931, showed: In right chest, diminished expansion in the upper part, with diminished resonance. Distant

whispered pectoriloquy in upper part, and a few fine medium râles in mid-portion and coarse râles in upper. Under the fluoroscope, right diaphragm motion slightly restricted. Weight 92 pounds (normal 98).

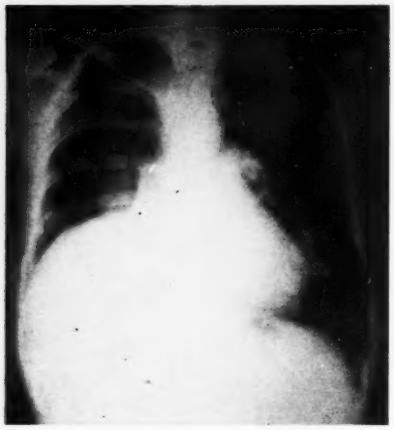

Fig. 11. Case 4, May 16, 1931. Shows rise in diaphragm following phrenic exeresis: cavity not closed.

Roentgenogram (Fig. 13) Sept. 5, 1929, showed base of heart displaced to right and slight elevation of right diaphragm. In the mid-portion of the upper lobe there was a fairly homogeneous density, probably from a localized atelectasis, in which were areas of lesser density. There was some infiltration in the left lung behind the first rib. On Sept. 8, 1931, patient had a moderate hemorrhage.

On Sept. 10, 1931, pneumothorax was instituted on the right side. The initial manometer reading was —10 —7. Patient was given 200 c.c. of air, and the reading was —5 —3. Fluoroscopic examination on Sept. 13, 1931, showed a partial compression of the upper lobe; heart and mediastinum in normal position. Pneumothorax has been continued.

Roentgenogram (Fig. 14) taken Jan. 9, 1930, shows a partial collapse of the right lung, with adhesions in the apex; the heart in normal position and the diaphragm slightly depressed. A phrenic exeresis has recently been done with the idea of discontinuing the pneumothorax. Patient has made marked improvement, does not cough, and has no expectoration. It will be interesting to see if reexpansion will occur when pneumothorax is discontinued.

The area in the right upper lobe would probably be considered a pneumonic area by many, but we believe that it is possibly a partial or localized atelectasis, with some pneumonic infiltration and cavitation. The demonstration of the displaced heart and trachea, with the slight elevation of the diaphragm and the marked negative initial pneumothorax readings, strengthen the possibility of an atelectasis. A simple pneumonic infiltration would not as a rule cause displacement of the heart and trachea or elevation of the diaphragm.

Case 6. E. N.,[5] female, aged 32. Developed tuberculosis in December, 1928, and under rest treatment improved slightly. Had intermittent pain in both sides of the chest. For the past few months has had periodic upsets, with chills and high temperature, which would last a few days. She noticed that her sputum was decreased at these times: raised about four ounces sputum daily.

Chest examination Oct. 14, 1930, revealed a few scattered râles over the right lung. On the left there was dullness, base up, and diminished breath sounds. A few crackles were heard over the left lung.

Roentgenogram (Fig. 15) taken on Oct. 15, 1930, showed opacity of the left lung, in which could be seen a fairly large cavity. The heart was displaced to the left and the diaphragm was high.

Patient's weight was 128 (normal, 130). Sputum was positive. She usually ran a daily temperature, and continued having periods when she would run high temperature with reduction of sputum, due to blocked drainage. Artificial pneumothorax was attempted a number of times, but there was no pleural space free. A left phrenic exeresis was done Nov. 12, 1930, resulting in only a slight rise of the diaphragm; and there was no further improvement. On June 15 a thoracoplasty was done; recovery was good. Since then the patient has been greatly improved, with a marked reduction in sputum. Temperature has been normal, and she is now on exercise.

[5]Part of this case previously reported.

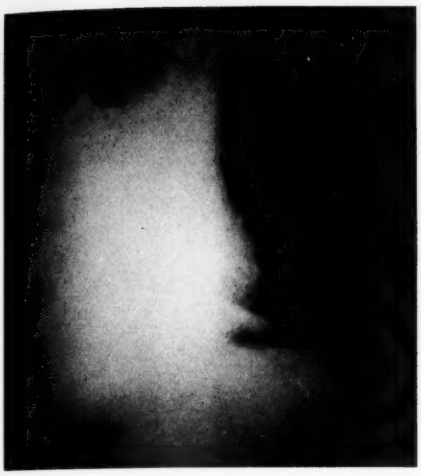

Fig. 12. Case 4, Nov. 23, 1931. Return of displacement of viscera after discontinuing pneumothorax: cavity in apex increased in size.

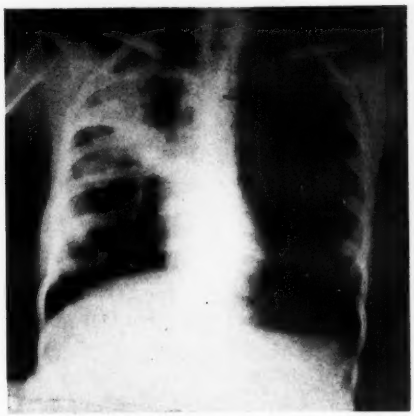

Fig. 13. Case 5, Sept. 5, 1929. Triangular atelectatic area in right upper lobe: cavities present in opaque area: slight cardiac displacement and elevation of the right diaphragm.

Roentgenogram (Fig. 16) taken Sept. 22, 1931, shows the result of the thoracoplasty on the left. In this case films taken prior to the atelectasis could not be obtained, and a careful history did not reveal the time of its occurrence.

Case 7. A. G., male, aged 30. First seen April 27, 1928. Tuberculosis first diagnosed in 1923. Had severe cough and loss of weight. Treatment consisted chiefly of rest. Had pleurisy at various times on both sides. No history of acute upsets or hemorrhage. Weight 151 (normal, 156). Examination showed diminished expansion of the left chest, with dullness, apex to base. The breath sounds were absent in the base and amphoric in the apex: few fine medium râles in the apex.

Roentgenogram (Fig. 17) taken May 5, 1928, shows a marked opacity over the left lung, with heart and trachea displaced into left chest. Diaphragm was high. In the apex there were areas of lesser density, suggestive of cavitation. Sputum was positive. Temperature ranged to 100, pulse 95. Patient coughed considerably, and expectorated about two ounces daily. Had periodic upsets of temperature and gastric disturbances.

From pneumothorax, instituted June 6, 1928, the initial reading could not be obtained, due to marked negative pressure. Patient was given 300 c.c. of air, and the resultant reading was —5 —4. Heart and trachea returned to normal position, as seen under the fluoroscope.

Roentgenogram (Fig. 18) August 24, 1928, shows three-fourths compression of left lung; cavities in apex held open by adhesions; heart in normal position; left diaphragm depressed. Later fluid developed, but the pneumothorax was continued with frequent aspiration until March, 1930. Air pocket decreased in size slowly.

There was marked clinical improvement: sputum became negative. Pneumothorax was discontinued because of loss of pleural space and difficulty in obtaining reading. Roentgenogram taken Feb. 1, 1930, shows heart and trachea displaced to right and diaphragm elevated. There is an area of pneumothorax along the lateral border. The left lung is still opaque.

On May 24, 1930, a left phrenic exeresis was done, and patient has still continued to improve. Weight is now 176; temperature normal; no cough or sputum.

Roentgenogram (Fig. 19) taken May 11, 1931, shows the atelectasis of the left lung, with contraction of the interspaces and sco-

Fig. 14. Case 5, Jan. 9, 1930. Shows return to normal position of viscera and closure of cavities by artificial pneumothorax.

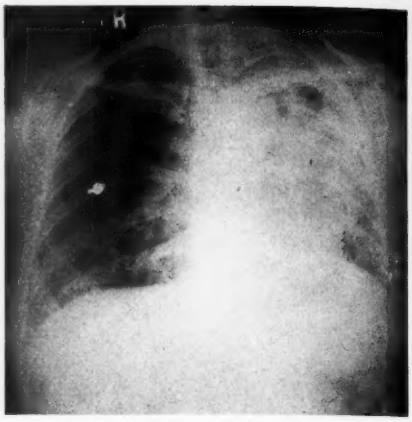

Fig. 15. Case 6, Oct. 15, 1930. Atelectasis left upper lobe, with cavities.

liosis of the spine to the right; no cavities are visible.

This case also shows the value of artificial pneumothorax, and that re-expansion did not occur with discontinuance of pneumothorax.

Case 8. E. W., male, aged 29. Tuberculosis first developed in 1926, with right pleurisy, cough, and loss of weight. Sputum was positive. Patient rested for three years, but had periodic upsets. Examination on Nov. 2, 1929, showed resonance fair over both lungs. There were a few medium râles over the right upper portion. In the apex of the left lung there was a distant bronchial breathing. Over the entire left lung there were medium coarse râles. Fluoroscopic examination showed good motion of both diaphragms, with scattered infiltration through the left lung. Heart was in normal position.

Roentgenogram taken May 29, 1929, showed scattered small calcified areas over the right lung. The aortic area was widened. In the left apex a cavity was seen, and scattered throughout the left were areas of infiltration. Amount of sputum in 24 hours was 2 ounces.

On Dec. 14, 1929, patient developed a cough and temperature rose to 100°. Examination revealed diminished breath sounds in left base. Two days later cavity signs developed in the apex of the left lung, and the heart was found shifted to the left. Temperature was 101°. Cough was harsh and patient became slightly hoarse. Some blood was present in sputum. A friction rub developed over the precordium. Examination made on Dec. 30, 1929, showed dullness over the entire back and reaching into the axilla on the left. The breath sounds over the entire back were bronchial in character, and there were coarse râles over the anterior chest. The heart was markedly displaced to the left. Temperature persisted about 103°; pulse 136.

Patient was seen every few days following this, and showed some slight improvement. Lung condition remained the same. He was moved to the hospital on Jan. 14, 1930, where a roentgenogram was taken. This showed a massive atelectasis of the left lung; heart markedly displaced to the left. Part of the right lung could be seen to the left of the spine. In the left apex was a large cavity: diaphragm was not visualized. Patient remained in the hospital, temperature ranging from 99° to 102°; pulse from 100 to 120. Fluoroscopic examination later showed condition of lung about the same, except cavity in left apex was slightly larger: diaphragm was elevated. Pneumothorax was attempted Feb. 7, 1930, but patient fainted and it was not attempted again. Patient gained only slightly,

Fig. 16. Case 6, Sept. 22, 1931. Result of thoracoplasty on the left.

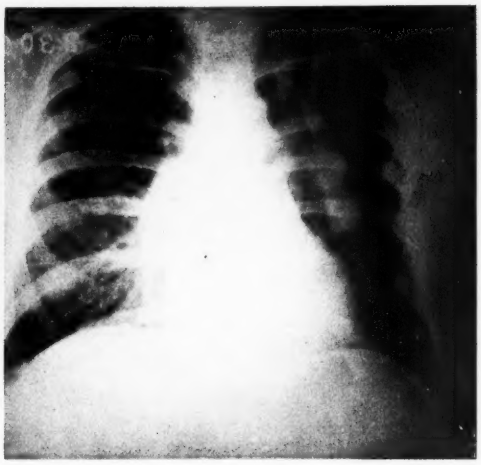

Fig. 18. Case 7, Aug. 24, 1928. Results of artificial pneumothorax on the left.

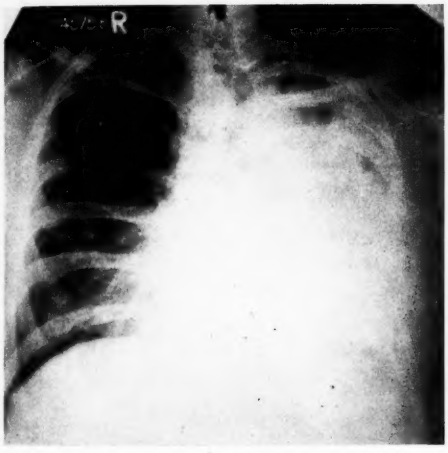

Fig. 17. Case 7, May 5, 1928. Atelectasis of left lung: cavity in apex: trachea, heart, and right pulmonary artery displaced to left.

Fig. 19. Case 7, May 11, 1931. Shows displacement of viscera, with complete absorption of pneumothorax: scoliosis to right. Case apparently arrested.

and on March 7, 1930, died of a massive hemorrhage.

This case probably shows a gradual development of a massive atelectasis as described by Glenn (7). Its onset was stormy, being first mistaken for pneumonia. Had we been in a position to have taken a roentgenogram at the time of atelectasis, we would undoubtedly have found more than the physical signs indicated at first.

Case 9. J. W., male, aged 34. Tuberculosis first developed in 1924. Under rest treatment, condition did not improve. Some pleurisy at that time on left side, and an occasional small hemorrhage. Physical examination as recorded in October, 1926, showed slight impairment of resonance over left lung, breath sounds being slightly diminished in the left lower. In the right upper part of the chest there were medium coarse râles: right side

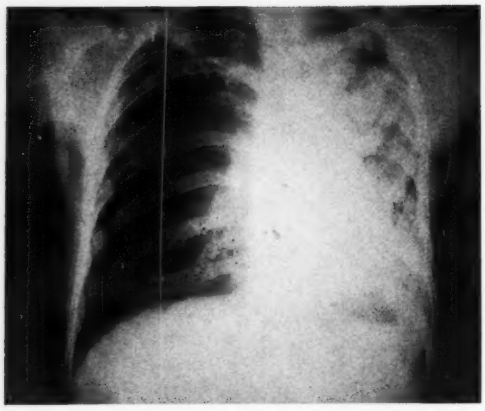

Fig. 20. Case 9, Oct., 1926. Area of atelectasis in left lung; displacement of heart and diaphragm: cavity behind second interspace on the left.

Fig. 21. Case 9, July, 1931. Shows marked displacement of heart, trachea, and right pulmonary artery, with arrest of disease following a spontaneous pneumothorax which later absorbed. Diaphragm not visualized.

showed a few medium râles in the apex: sputum was positive, and weight was 110.

Roentgenogram (Fig. 20), in October, 1926, showed heart and trachea displaced to the left, with diaphragm elevated.

In the right apex there was slight fibrous infiltration. The left lung field was contracted and there were numerous areas of what appeared to be caseous infiltration scattered throughout. There was a cavity behind the second rib on the left, and a fairly heavy density in the base. The cardiac displacement and the elevated diaphragm indicate an atelectasis and undoubtedly the areas first considered small areas of caseous pneumonia were in reality atelectatic. Under rest treatment condition remained about the same. Patient was an ideal case for pneumothorax, yet he refused.

In September, 1929, he had a severe hemorrhage, and also developed severe pain in left chest, with shortness of breath. Percussion note was hyperresonant. A diagnosis of spontaneous pneumothorax was made. Air and (later) fluid were withdrawn from the left pleural cavity a number of times. Patient had rather a stormy time, but soon began to show improvement, which has continued to the present time.

Roentgenogram (Fig. 21) taken in July, 1931, shows heart extremely displaced into left chest, marked deviation of the trachea, and left diaphragm high. The right lung is emphysematous and extends beyond the spine on the left side; the left lung is opaque and contracted; the interspaces on the left are narrowed. At the present time patient is symptom-free except for slight dyspnea. Sputum is persistently negative and the temperature normal. This can be considered an arrested case. It demonstrates two things: the development of a spontaneous pneumothorax on an atelectasis, and the phenomenon seen in pneumothorax cases in which the lung does not re-expand. A displacement similar to that of massive atelectasis occurred, due to the marked negative pressure produced by the absorption of the air contained in the pleura. Undoubtedly this lung is now a hard fibrotic mass, the same as seen in an atelectatic lung which does not re-expand.

The main difference between these two types is that in atelectasis the air in the lung cells is absorbed, producing the marked negative pressure, while in the case of pneumothorax in which the lung has become fibrotic, the air in the pleural cavity is absorbed.

SUMMARY AND CONCLUSIONS

Atelectasis has in the last few years taken its place as a complication of pulmonary tuberculosis, and offers an explanation of many of the heretofore obscure opacities as seen in the roentgenogram. It undoubtedly is the chief cause of pulmonary fibrosis, either localized or massive, in cases in which there is displacement of the mediastinum, trachea, and heart toward the affected side, or elevation of the diaphragm. Its onset is usually sudden, with few symptoms. It may, however, occur successively in smaller or larger areas and is thought, therefore, to develop gradually. Scoliosis of the spine may be the result of an atelectasis.

Its effect on tuberculosis may be beneficial and cause arrest of the disease: in cases in which its effect is opposite, some form of artificial compression of the lung offers the best results. Undoubtedly in cases in which a localized or partial atelectasis exists, with an open cavity, artificial pneumothorax should be instituted before the possible occurrence of a massive atelectasis, with the hope that when the disease becomes arrested and the pneumothorax is discontinued, re-expansion of the compressed lung will result.

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DISCUSSION

Dr. Henry Snure (Los Angeles, Calif.): Dr. Gatterdam's theories that the bronchial obstruction in tuberculosis is due to clot-forming hemorrhage, caseous plug, pressure from enlarged lymph glands, plugging by tenacious sputum, and scar formation seem logical in view of what we know about atelectasis following abdominal operations, etc. One author, however, reports seven cases in which bronchoscopic examination was done and no visible plugging of the bronchus was found.

Dr. Gatterdam treated nearly all his cases by pneumothorax following the primary atelectasis. It is to be noted that the Koch bacillus has a tendency to encourage fibrous tissue formation, which may account for the fact that in all but one of his cases the collapse was permanent. However, in the removal of bronchial tumors accompanied by collapse for weeks and secondary non-tuberculous infection in the collapsed lung, the latter will re-expand after the obstruction has been removed. Due to fear of spreading the infection, it would, perhaps, be unwise to use Sante's method of re-expanding a collapsed lobe in the tuberculous types of atelectasis. The use of the bronchoscope in tuberculous lung infections might also be questioned.

Dr. Gatterdam has been fortunate in observing most of his cases in his sanatorium. In a typical case, he reports that a routine film was made of a certain patient, and the heart was found to be in its proper position. A few days later the patient had a slight rise in temperature with slight pain. A repeat film showed collapse of the lower left lobe, with the heart markedly displaced toward the left axilla. To and fro movement of the heart was noted on the fluoroscopic examination. Apparently these slight reactions to collapse are due to the fact that the patient had been at rest for a long period and small areas of the lobe involved were already in a state of collapse, so that complete collapse caused little

reaction. In my work in a general hospital, if I were to see such a case brought in with tuberculous changes in the lungs, I would be inclined to believe that displacement of the heart was due to a fibrosis pulling the heart over, rather than a collapsed lobe. No doubt I have made such mistakes in the past.

Now that atelectasis in tuberculosis has been called to our attention, I am sure that we will all be looking for such a condition in the future and many more cases will be reported.

Dr. M. L. Pindell (Los Angeles, Calif.): I am reluctant to discuss Dr. Gatterdam's paper, for I have recognized only a few cases of atelectasis in my work in tuberculosis, and, therefore, feel that I am not qualified.

In 1930, my attention was first called to atelectasis on a large scale in an exhibit made by the University of California, adjoining one I had on tuberculosis. I asked the exhibitor if he could pick out any cases of atelectasis in my exhibit. The result was that he found two which he thought were atelectatic lungs.

I think we should give Dr. Gatterdam a great deal of credit for elaborating on this rather new subject. He has shown many cases, and most of them appear to be proven (the cases that have occurred over-night). Therefore, there is no doubt but that atelectasis occurs more frequently than we have thought, especially partial atelectasis. Perhaps, in many cases of the latter in tuberculosis, the plugging is in the terminal bronchi, and for this reason the bronchoscopist has failed to locate the trouble.

It seems good to have a roentgenologist call our attention to this condition. The study of the living is many times more enlightening than the study of the dead. The pathologist has called our attention to collapsed lungs, but his opinion was overwhelmingly in favor of fibrosis and adhesive collapse.

Dr. B. A. Rhinehart (Little Rock, Ark.): Dr. Gatterdam has told us how some of these cavities grew larger, and how some of them, according to his opinion, grew far down. It seems to me that the enlargement of the cavities is probably another retractive phenomenon. We know that there are tremendous static forces of retractive nature in these cases of massive collapse. Under such conditions, with retraction enlarging cavities, it appears there is no hope for the cavities other than surgery. I would like to ask if my conception of that is correct.

I remember one case in the medical school. The patient had a narrow band of dense tissue down the left side of the thorax. The heart and mediastinal structures were displaced completely to the left side, with a part of the right lung appearing to the left of the sternum. Fortunately, she did not have a cavity.

I would like to have you answer the above question, if you please.

Dr. Maxim Pollak (Peoria, Ill.): I believe that, in addition to the type of cases Dr. Gatterdam has shown, we meet with atelectasis rather frequently in the course of artificial pneumothorax treatment. When we collapse the lung to such a high degree that it shows up on the x-ray film as a small dense shadow, we have produced an artificial atelectasis by our treatment.

I would like to ask the Doctor if he has seen the shifting of the mediastinal structures to a normal position with the use of phrenicoexeresis.

I have under my observation a case of massive atelectasis which developed last February, in which the heart is entirely on the right side, the afflicted side. We have tried to do everything in that particular case, including pneumothorax, but we have not succeeded in relieving the condition. I am wondering if, with phrenicotomy, we could shift back the mediastinal structures to their normal position.

Dr. Paul C. Hodges (Chicago, Ill.): I have been brought up to believe that the mediastinal displacement to the affected side, so frequently seen late in unilateral tuberculosis, is due to fibrosis of lung and pleura followed by contraction of fibrous tissue. But Dr. Gatterdam proves conclusively that, in many cases at least, the condition is atelectasis without pleural adhesions. Some of his slides in which the roentgenogram made after pneumo-

thorax demonstrates a completely atelectatic lung without any evidence whatever of pleural adhesions, are literally astonishing.

DR. GATTERDAM (closing): In answer to Dr. Snure's question regarding the presence of tuberculosis elsewhere in the lung, we find that cavities are usually visible in the upper lung field of the involved side. There also is usually infiltration or caseation present in other parts of the lung. In addition, there may be activity in the opposite lung.

The case in which the atelectatic lung re-expanded was reported previously. It occurred following a hemorrhage. Artificial pneumothorax was attempted but was unsuccessful because of lack of free pleural space. A phrenico-exeresis was done, followed by a blood transfusion. The atelectasis occurred three days following, and aeration did not take place until about ten days later. Unfortunately we could not follow this case roentgenographically during this time, but, from physical examination, aeration seemed to progress slowly.

As stated before, cavities, especially those in an upper lobe, that are not closed by the atelectasis as a rule tend to enlarge. Contraction of the lung undoubtedly plays an important part in this enlargement, primarily caused by the marked negative pressure, and, possibly, secondarily by the resultant fibrosis which occurs.

If atelectasis has occurred, cavities previous-present may have become closed or may not be seen through the opacity. Of course, we must remember that in the cases here reported tuberculosis was only considered. Atelectasis may occur in any chronic lung infection such as bronchiectasis, malignancy, or abscess formation. In tuberculosis, if cavities are not seen following an atelectasis, in all probability they will be found if an earlier film has been made. However, I do not wish to make the statement that a cavity must be present.

In cases in which phrenico-exeresis is done, we have not seen the heart and mediastinum return to their normal positions. The additional rise or paralysis of the diaphragm many times helps to close cavities.

If possible we should determine whether or not atelectasis is likely to occur and institute pneumothorax before its development. It is possible, if this is done, that re-expansion of the lung may occur when the pneumothorax is discontinued, whereas after it is instituted on an atelectatic lung, re-expansion is not the rule.

WHOLE ANIMAL EXPOSURES TO HIGHLY FILTERED GAMMA RAYS[1]

By W. G. WHITMAN, M.D., School of Hygiene and Public Health, Johns Hopkins University, BALTIMORE

I. INTRODUCTION

SINCE the development of high voltage x-ray tubes operating at voltages of the order of a million volts, the question of adequate protection for those engaged in this work against the very penetrating gamma-rays which are produced, an appreciable fraction of which passes through whatever shielding may be used, has become of considerable importance. More and more laboratories are expending efforts in this direction, a development which makes not only possible but practical the use of such tubes for medical applications. Roughly speaking, an x-ray tube operating at a million volts and 4 ma. gives off as much radiation as would be obtained from 1,000 grams of radium, and when 4 or 5 inches of lead is used to shield only 4 or 5 grams of radium the magnitude of the protection problem for those working with such tubes is readily seen.

For this reason it seemed valuable to per-

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931. Also before the Society of Hygiene of the Johns Hopkins University, Dec. 17, 1931.

form some experiments with highly filtered gamma-rays from radium in order to ascertain the dangers from exposure to such penetrating radiation. Estimates of the protective measures required and the dangers involved doubtless might be made from previous work, but for comparison it appeared desirable to have data on exposures to gamma-rays from radium from which all soft components were filtered out, thus approximating the quality of the radiation which passes through the protective screening of a very high voltage tube.

It may be well to point out that in the usual clinical application of radium without heavy filtration a considerable part of the radiation has a wave length equivalent of from 300,000 to 600,000 volts. Filtering with 16 mm. of lead, as was done in these experiments, raises the average hardness of the radiation to a wave length equivalent of about 1,250,000 volts. Data for even the gross biologic effects of whole-body exposure to radiation of this hardness of voltage-equivalent do not appear to be available in the literature. It might also be remarked that an x-ray tube operated at, say, 1,500,000 volts will give out most of its radiation in the region below 1,000,000 volts, and, due to the lack of filters of higher atomic number than lead, even extremely great filtration will hardly raise the average hardness of the radiation to a wave length equivalent of 1,000,000 volts. The experiments here described may consequently be considered as a valid attempt to obtain primary data of interest in connection with the protection problem as indicated.

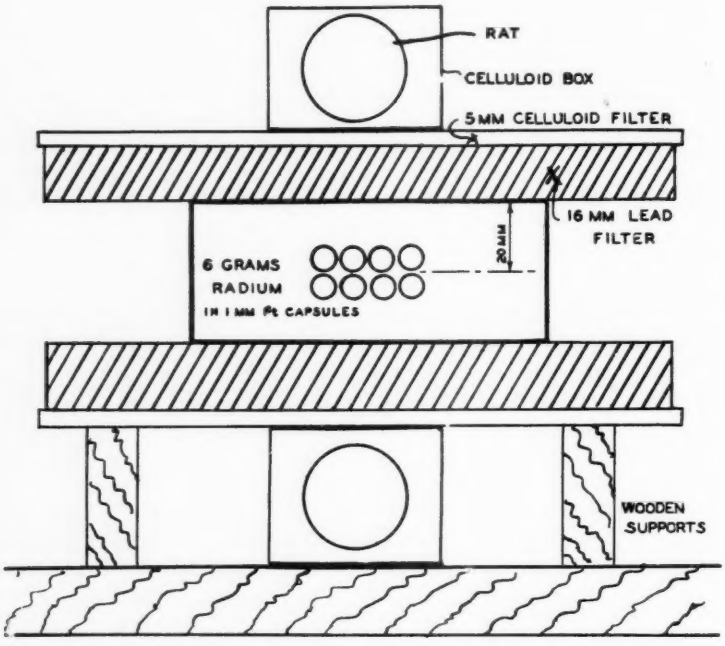

Fig. 1. Diagram showing method of exposure of rats to radium.

II. METHOD OF EXPOSURE

A total of 83 rats was used in these experiments. The stock originally came from the Wistar Institute but had been carried for twelve years by the School of Hygiene

and Public Health of the Johns Hopkins University as a stock colony for the Department of Physiology. Of these rats, 38 averaged 111 days at date of irradiation, 28 averaged 64 days, and 17 were approximately 44 days old. A group of 63 rats, made up of the 38 oldest, 17 youngest, and 8 of the 64-day-old rats, was exposed to 6 grams of radium filtered through 1 mm. platinum, 1 mm. brass, 16 mm. lead, and 5 mm. celluloid at an average distance of 41 mm. from the midpoint of the radium to the nearest side of the rat. For 4 additional 64-day-old rats the celluloid was omitted. The rats were put in celluloid boxes 47 mm. high, placed above and below the radium box. The radium capsules were spread out over a surface 3 by 10 cm. to give a more uniform exposure. With this large source area and average distance, the exposure was reasonably similar (to within about 50 per cent) throughout the entire body of the rat (Fig. 1).

In addition, 16 of the 64-day-old rats were exposed to 2.5 grams of radium at the same distance but with the lead filters removed, and for 8 of this group the celluloid was omitted. Because of the removal of the lead absorption-filters, this group of rats received approximately the same exposure to the hard components of the radiation as the first group using 6 grams of radium and the lead filters, but with the addition of that amount of soft radiation which penetrated the platinum and the brass. The celluloid was used in order to reduce the beta-ray intensity to about the level corresponding to the rate of beta-ray production in the tissues. Exposure times were varied from 0.5 minute to 17 hours in a roughly geometrical progression. It was calculated according to ordinary clinical data that the 2.5 grams of

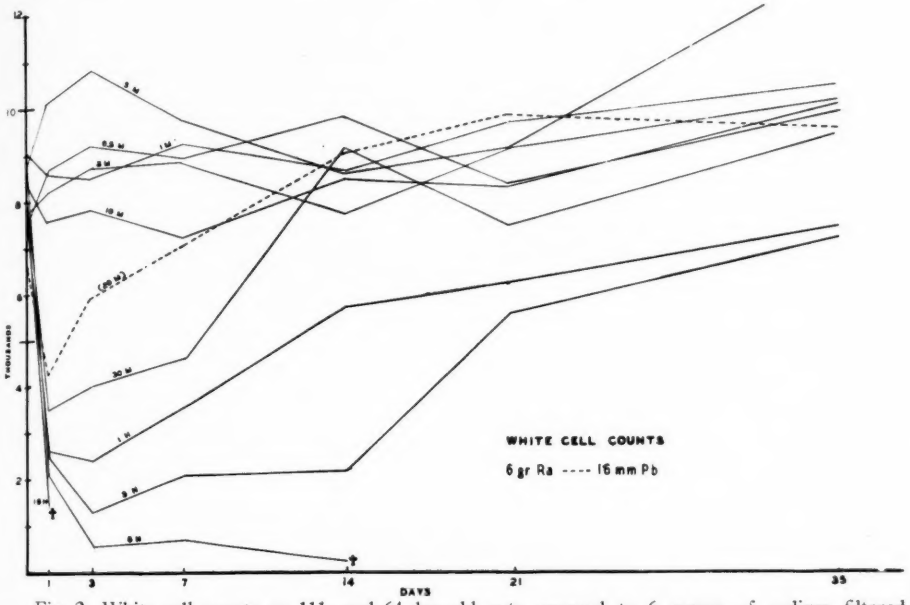

Fig. 2. White cell counts on 111- and 64-day-old rats exposed to 6 grams of radium filtered through 1 mm. platinum, 1 mm. brass, 16 mm. lead, and 5 mm. celluloid. Distance = 62 mm. to midposition of rat. Exposure times, 0.5 minute to 16 hours. Average hardness of filtered radiation had a wave length equivalent of 1,250,000 volts.
Abscissæ: days after radiation.
Ordinates: white cell counts in thousands per cu. mm. blood.

radium without the lead filter should give an erythema dose in about four hours at the average distance to the middle of the rat of about 6 centimeters.

III. RESULTS

(A) Lethal Dose.—All rats died which were exposed to 6 grams of radium for 6 hours or longer. With a 16-hour exposure, radium, with filters, therefore, may be taken to lie between 3 and 6 hours. For definiteness, the lethal exposure time under these conditions was taken as 4 hours. Of 4 rats exposed to the 2.5 grams of radium without the lead filter for two hours, 2 died from anemia 19 and 37 days, respectively, after irradiation. The lethal exposure for these conditions was taken as 3 hours.

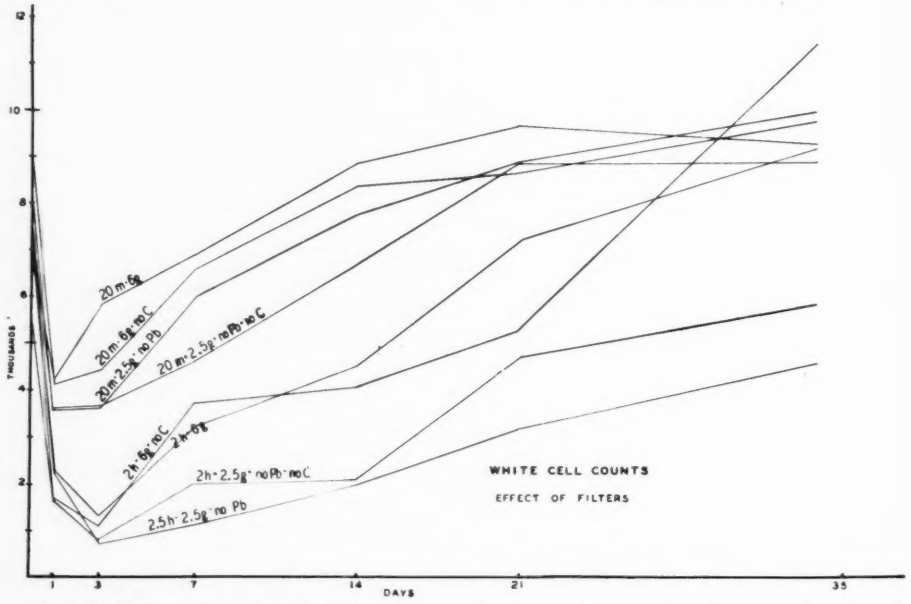

Fig. 3. White cell counts on 64-day-old rats showing that exposure to 6 grams of radium filtered through 1 mm. platinum, 1 mm. brass, and 16 mm. lead is practically equivalent to exposure to 2.5 grams of radium filtered through 1 mm. platinum and 1 mm. brass, although rats exposed to radiation containing softer components (2.5 grams, no Pb) showed slower recovery to normal count.
Abscissæ: days after radiation.
Ordinates: white cell counts in thousands per cu. mm. blood.

death ensued in from 2 to 4 days, due (at least in part) to injury to the gastro-intestinal tract. On autopsy these rats showed enormously dilated stomachs, filled with food, and hemorrhages throughout the mucous membranes. Rats which were exposed 6 hours showed some gastro-intestinal symptoms, with diarrhea, but these cleared up in about three days and the rats died from 1 to 3 weeks later with an aplastic anemia. One of the rats exposed 3 hours died from a similar anemia at the end of 11 days. The lethal exposure for 6 grams of

It might be mentioned that in none of the rats were skin effects or burns noted.

(B) Blood Counts.—It is customary to regard the blood count, especially the white cell count, as perhaps the most sensitive biologic indicator of radiation exposure. Accordingly, blood counts were made on 66 rats. All the blood counts were made on the 111-day-old rats except the 20-minute group, which was a 64-day-old group. The exposure arrangement was the same as previously noted. Counts were made before exposure, 0, 1, 3, 7, 14, 21, and 35 days

after exposure. The count at 0 days was made from 1 to 4 hours after the end of the irradiation. Since a single massive dose is presumably more favorable for causing a detectable change in blood count than the same dosage distributed over a considerable period of time, these observations should give the limiting sensitivity of the blood count method for detecting radiation exposure with rats. The minimum exposure which showed a definite fall in the white cell count was about twenty minutes for the rats exposed to 6 grams of radium, with filters. It is possible that with a larger group of rats than was used in this test an exposure of 10 minutes would show a change which could be considered definite. The white cell counts, averaged for each group having a different exposure time, are plotted in Figure 2. For each of the lowest exposure times only 2 rats were used; for exposures of from 10 to 30 minutes, 4 rats were in each group, and for the longer exposure times at least 6 rats were used in each group. It would appear that since with rats even single doses as large as one-twentieth of a lethal dose are likely to escape detection when groups of 4 individuals are used, a dependence on blood counts alone as a danger sign for workers with high voltage tubes may allow an unduly large total exposure to occur unnoticed. This is particularly true since the possible cumulative effects of exposure to hard radiation of this type are so far unknown. Although one cannot draw any definite conclusions from the small low-exposure groups, it is interesting to note that there is an increase in white cell count for exposures of 5 minutes and less.

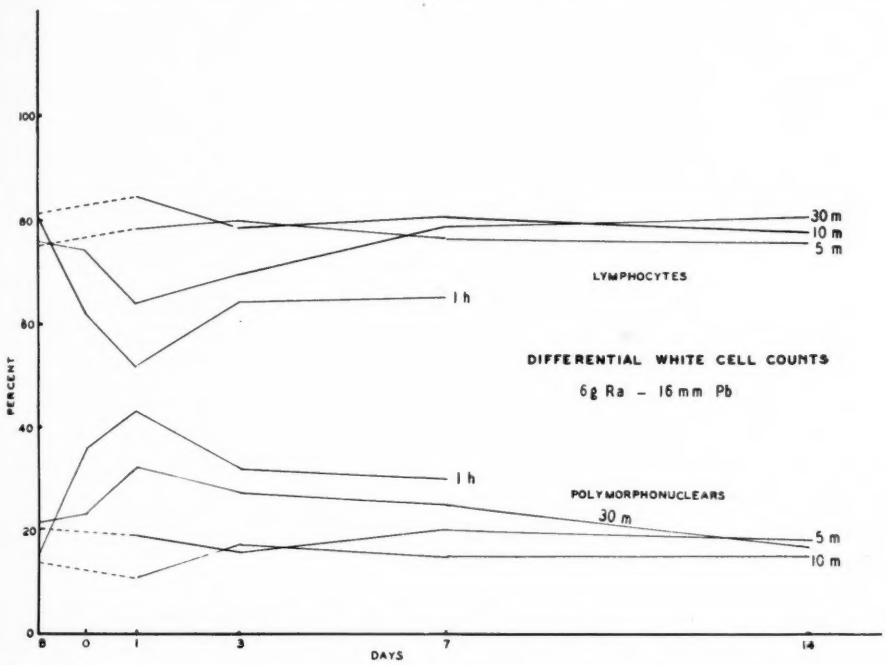

Fig. 4. Differential white cell counts on rats exposed to heavily filtered radiation (6 grams radium, 16 mm. lead, 1 mm. platinum, 1 mm. brass, 5 mm. celluloid). Exposure time, 5 minutes to 1 hour.
Abscissæ: days after exposure.
Ordinates: differential white cell counts.

In order to evaluate crudely the relative importance of the components of the gamma-radiation and of the secondary beta-

radiation from the filters, eliminated in the above experiments using all filters, several groups of rats were exposed omitting separately the lead and celluloid filters. Rats for these experiments averaged 64 days of age. Two groups of rats, exposed 20 minutes and 2 hours, respectively, to 6 grams of radium without the celluloid filter, showed no definite difference from the control rats exposed using the celluloid, which served to reduce the secondary beta-ray intensity to approximately that produced in the tissues themselves. When the 16 mm. lead filter was omitted the total quantity of radium was reduced to 2.5 grams, which, by calculation from the known lead absorption coefficients for the lines of the radium gamma-ray spectrum, should reduce the intensity of the penetrating components to nearly the same level as when the 6 grams of radium are used with the lead, with, however, the rat being exposed to such additional softer components as pass through the 1 mm. of platinum and 1 mm. of brass. The latter filters could not be eliminated in our experimental arrangement. These data are shown in Figure 3.

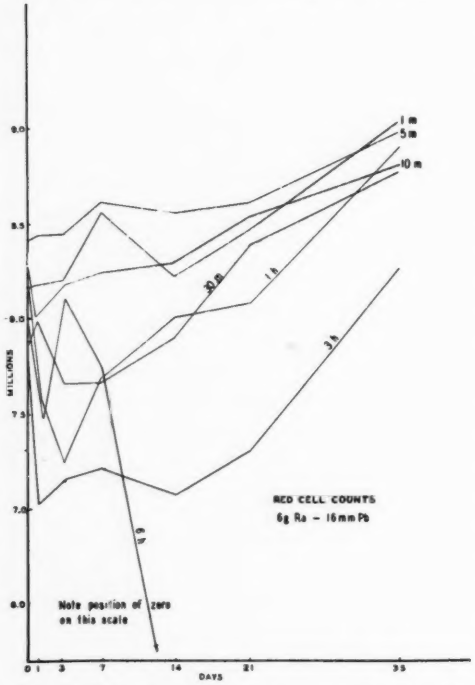

Fig. 5. Red cell counts on rats exposed to heavily filtered radiation (6 grams radium, 16 mm. lead, 1 mm. platinum, 1 mm. brass, 5 mm. celluloid). Exposure times, 1 minute to 6 hours.
Abscissæ: days after exposure.
Ordinates: red cells in millions per cubic millimeters.

Differential blood counts were made on selected groups of the rats exposed to the 6 grams of radium, with filters, in order to ascertain whether such a test was more sensitive than the total white count. From the curves of Figure 4 it appears that for this heavily filtered radiation the differential count is not appreciably more sensitive than the total white count.

It is a matter of common experience that the erythrocyte count is less sensitive to ordinary x-ray exposure than the leukocyte count. A similar result was found for the radiation used in these experiments. That the red blood cell counts were consistent with the white cell counts may be seen from Figure 5. Short exposures produced a slight rise and exposures of 30 minutes or more a marked fall, which increased in degree and duration with exposure time.

(C) Weight Changes.—It may be of interest to remark that with a homogeneous group of rats, such as were used in this experiment, during the significant early period following an exposure to radiation the weight changes were nearly as sensitive an indicator as the leukocyte counts. Lacking a sufficient number of unexposed controls, the groups having an exposure of 5 minutes or less were used as a norm for the rate of growth. This is Curve A of Figure 6. The curves show the weight changes for the various groups of the 111-day-old rats for a period of one week immediately following exposure. A straight line of the same slope as Curve A is drawn through the point which gives the average weight of each group on the day of exposure. It is seen that the other groups fail to gain weight as

rapidly as Group A, roughly in proportion to their exposures, and that an exposure of 30 minutes produces at least as obvious a change in the weight curve as the change in white cell count of the 20-minute group of Figure 3.

(D) Estrous Cycle and Breeding Experiments.—Using the standard technic for determining estrus in rats by daily smears, the estrous cycle was followed for 50 days after irradiation in the females which had reached maturity before exposure, and definite normal cycles were found in all rats regardless of the amount of radiation.

Data on smaller rats show some evidence that even a moderate exposure of female rats averaging 44 days old on date of exposure delays the opening of the vagina to from 130 to 140 days (the average age for this occurrence is 72 days with a range of from 34 to 109 days).[2]

The rats were not bred until at least one month had elapsed after irradiation. Some rats in each exposure group were bred 3 months or longer after exposure. In rats which averaged 111 days at irradiation, exposed for 1 and 3 hours, respectively, to 6 grams of radium, with filters (total 11; 6 females, 5 males), all of the individuals proved fertile, although 2 of the 6 females showed what is termed "one-time sterility." Hence the sterilizing dose appears to be not appreciably less than the lethal dose for whole body exposure to this penetrating radiation. In view of the observations of Ford and Drips[3] on white rats, it is clear, however, that these meager observations can set only approximate limits on the sterilizing dose.

In the 2-hour group in which the rats averaged 64 days of age on irradiation, 4 of the 6 rats exposed to 6 grams of radium, with the lead filter, were sterile, and 3 of the 6 exposed to 2.5 grams, without the lead filter, were sterile. It is probably without significance, but should be remarked, that of these, the 3 sterile rats were exposed without the celluloid, the fertile three with the celluloid. In the 6-gram group, only 2 of the 4 sterile rats were exposed without the celluloid. These data merely suggest that young rats which have not reached the breeding age or have barely reached it before irradiation are more easily sterilized than rats which have reached the breeding age before irradiation.

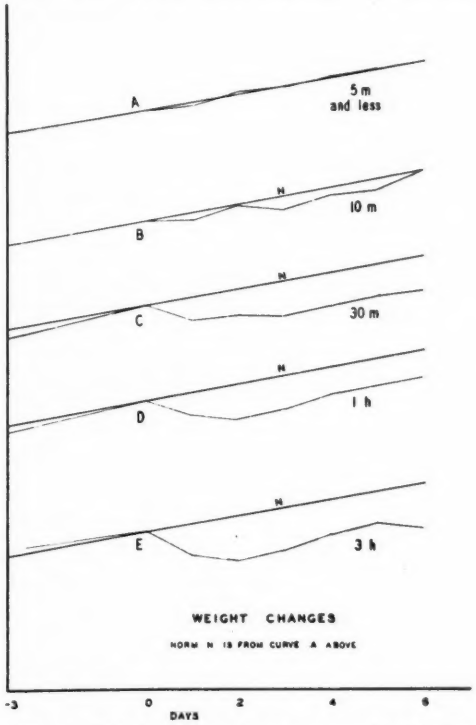

Fig. 6. Weight changes in rats exposed to heavily filtered radiation (6 grams radium filtered through 16 mm. lead, 1 mm. platinum, 1 mm. brass, and 5 mm. celluloid). Exposure times, 5 minutes to 3 hours. N = normal weight curve taken from Group A.
Abscissæ: days after exposure.

In order to ascertain whether or not an unusually great incidence of abnormal offspring is to be expected in rat families springing from stock irradiated by hard radiation, breeding experiments were carried as far as possible. In the progeny of the rats exposed 30 minutes or more, 7 abnor-

[2]H. H. Donaldson, The Rat, 1924.
[3]D. G. Drips and F. A. Ford, Proc. Staff Meet., Mayo Clinic, January, 1932, VII, 18-27.

mal rats occurred in 160 offspring. With rats exposed 20 minutes or less, one abnormal rat occurred in 91 offspring. Families showing abnormal rats were inbred and in 74 offspring in the third generation one abnormal was found. In 300 offspring of normal unexposed controls, one abnormal rat occurred.

Abnormalities noted were the absence of one eye or the presence of one large and one small eye. One rat was born with a short tail. These abnormalities occur at infrequent intervals in the parent stock. In both radiated and normal animals, the abnormals were females and the deformity occurred always in the right eye.

IV. CALIBRATION OF DENTAL FILMS

Since it was found that biologic methods of determining exposure for rats, particularly a dependence on white blood cell counts, allowed an exposure as large as one-twentieth of the lethal dose, even when given as a single massive dose, to be suffered without certainty of detection, it is clearly desirable to have a more reliable and sensitive indicator available and calibrated in terms of the lethal effect of this very penetrating radiation. The convenient use of dental film plaques in all x-ray laboratories as detectors of radiation leaks and the exposure of operators, made it desirable to develop a method for utilizing dental film with very hard radiation, providing a suitable calibration in terms of its biologic effect. Since soft radiation is photographically much more effective than hard radiation, it is important to measure separately the exposure of an operator to soft and to hard radiations. An unshielded dental plaque is a satisfactory detector for ordinary x-radiation, and a similar plaque well shielded by lead will serve to measure separately the penetrating gamma-rays. To provide a suitable index of exposure of operators to such penetrating radiation, a series of Eastman extra fast (CC) dental x-ray films was enclosed in a lead cassette having walls 6.9 mm. thick. This cassette was exposed in the mid-portion of the rat (6.2 cm. from center of radium to film) for periods of from 1/100,000th to 1/10th of the lethal exposure time as determined for the rats.[4] For these film exposures, 2.5 grams of radium were used with the 16 mm. lead filter (in addition to the cassette), and 12 hours was taken as the lethal exposure time with this smaller quantity of radium. This corresponds to a lethal exposure time of about five hours, using the 6 grams of radium, instead of the four hours, later adopted as more nearly correct and given earlier in this paper. An exposure of 1/1,000th of a lethal dose gives a point just at the lower end of the straight portion of the density *versus* log-exposure curve; that is, 7/10,000th lethal dose gives a density

[4] W. G. Whitman and M. A. Tuve, Physical Review, Feb. 1, 1931, XXXVII, 330.

TABLE I

Fraction of Lethal Exposure-time	Percentage Transmission Incident Film	Percentage Transmission Emergent Film	Average T	Density = $\log_{10} 1/T$
None	100	100	1.00	0.0
0.00005	100	100	1.00	0.0
0.0001	83	97	0.90	0.045
0.0003	65	83	0.74	0.13
0.0007	46	64	0.55	0.26
0.001	33	45	0.39	0.41
0.003	9.5	12	0.11	0.96
0.007	1.8	1.8	0.018	1.74
0.01	0.71	0.82	0.0075	2.12
0.05	0.028	0.033	0.0003	3.5
0.10	0.028	0.013	0.0002	3.7

easily confused with fog due to development, whereas 3/1,000th gives an obvious blackening of the film. The plaque was exposed as labelled with the black paper toward the tube (radium).

Densities as measured on a photo-electric photometer for the two films in each plaque are given in Table I.

Unfortunately, because of the alterations of photographic contrast introduced in the processes of half-tone reproduction, it is impossible to reproduce correctly the appearance of these films. Figure 7 gives a crude idea, however, for purposes of immediate reference, of the relative densities obtained with the given exposures.

V. SUMMARY

In order to determine some of the biologic effects of whole body exposure to very penetrating x-rays, unaccompanied by softer radiation, of practical interest in connection with the recent development of high voltage x-ray tubes, a group of 67 rats was exposed to the radiation from 6 grams of radium highly filtered by 16 mm. lead, 1 mm. platinum, 1 mm. brass, and 5 mm. celluloid. Another group of 16 rats was exposed to 2.5 grams of radium filtered by 1 mm. platinum and 1 mm. brass, giving a similar exposure to the hard gamma-rays, with the addition of such soft components as penetrate 1 mm. platinum and 1 mm. brass.

The lethal exposure was found to be 4 hours for 6 grams of radium, with filters, for a distance of 62 mm. to the mid-position of the rat. The minimum exposure which could be detected by blood counts was found to be 1/20th to 1/30th of a lethal dose.

For rats which have reached maturity before exposure, the sterilizing dose does not appear to be less than the lethal dose.

Breeding experiments were carried out with the result that the first progeny of rats exposed to more than one-tenth of a lethal dose showed a small increase in the number of abnormal offspring.

Dental films enclosed in a 7 mm. lead cassette were calibrated in terms of the lethal rat dose to serve as a more sensitive measure of the amount of exposure of laboratory workers to such hard radiations.

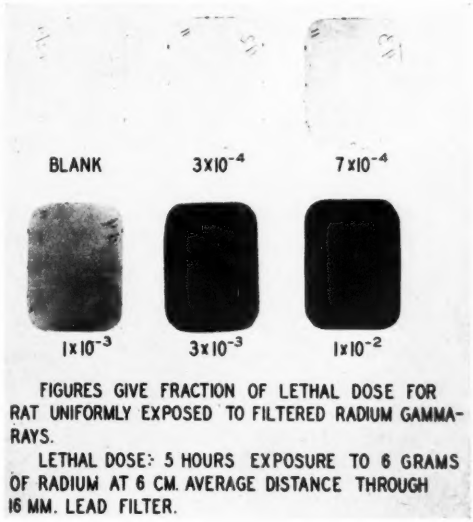
BLANK
3x10⁻⁴
7x10⁻⁴
1x10⁻³
3x10⁻³
1x10⁻²
FIGURES GIVE FRACTION OF LETHAL DOSE FOR RAT UNIFORMLY EXPOSED TO FILTERED RADIUM GAMMA-RAYS.
LETHAL DOSE: 5 HOURS EXPOSURE TO 6 GRAMS OF RADIUM AT 6 CM. AVERAGE DISTANCE THROUGH 16 MM. LEAD FILTER.

Fig. 7. Densities of photographic films exposed to definite fractions of a lethal rat dose.

Acknowledgments.—This work was carried out during the year 1930-31 at the School of Hygiene and Public Health of The Johns Hopkins University, under the supervision of Dr. Janet H. Clark, to whom the writer expresses her thanks. The award of a fellowship by the School of Hygiene and Public Health, which made this work possible, is gratefully acknowledged.

The writer also wishes to express her appreciation to the Department of Terrestrial Magnetism of the Carnegie Institution, of Washington, and to Dr. M. A. Tuve, of that Department, for facilities and assistance in connection with the physical aspects of this investigation.

SOME APPLICATIONS OF PHYSICAL THERAPY IN MEDICINE

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ARTHRITIS is one of the most troublesome conditions with which the orthopedist has to deal. If it is of the *traumatic, atrophic,* or *hypertrophic type,* good results usually follow static sparks for the relief of tension of the muscles surounding the joint. If it is of the *infectious type,* we are dealing with a general, and not a local, condition. In this case, a redundant and static colon may be as much the inciting factor as infected molars.

If the arthritis has destroyed cartilage, causing fibrosis and ankylosis, our treatment becomes more difficult and painstaking. We must wait for the acute stage to subside, then begin with passive massage and proceed to active exercise. In order to prevent further fibrosis, frequent and oft-repeated exercise is the key, especially in atrophic arthritis with deformity. A low protein diet might also be indicated.

Gonorrheal arthritis is usually chronic. Infra-red therapy, together with diathermy and static sparks, help in a majority of cases. To remember what can be done for disabling gonorrheal arthritis is to recall the work of Major Sampson, during the recent war. He requested that the gonorrheal arthritic patients who had received every form of treatment in the medical, surgical, and genito-urinary departments and were about to be discharged, 100 per cent disabled, be turned over to him. Upon proper physiotherapeutic measures being used—deep therapy lamps, infra-red rays, diathermy, and static massage to fibrosed joints—about 85 per cent were benefited and sent home 100 per cent efficient.

ELECTROSURGERY

Throughout the country, surgeons are beginning to profit by the methods of electrosurgery. From the smallest benign mole to the largest malignant infiltration, situated in almost any accessible portion of the body, we find electrosurgical methods indicated.

The two currents used in surgery are desiccation and coagulation. However, these electrical modalities are merely terms. We limit our term *desiccation* to the electrical destruction of benign or superficial growths in which the heat is of sufficient intensity to dehydrate the tissues. This is made possible by connecting our cord with a steel needle to the Oudin outlet of a diathermy machine. By regulation of fine sparks leaving our needle, we are able to remove warts, moles, vascular nevi, exostoses, papillomas, hemorrhoids, and infected tonsils, without even the formation of any discernible scars. Delicate bloodless dissections may be performed, as in the removal of sebaceous cysts, adenomas, or epitheliomas from the eyelids or nose. By using the negative pole of a galvanic machine, superfluous hairs may be rapidly and painlessly removed. A histological study of any growth after desiccation reveals such retrograde changes as shrinkage of cell walls, pyknosis, and cloudy swelling. However, although slightly distorted, the outline of the cell remains.

We also have our urologist desiccate papillomas of the bladder, our ophthalmologist corneal ulcers and growths, our gynecologist urethral caruncles, and our laryngologist small tumors on the vocal cords. The Oudin current is used for all these conditions.

ELECTROCOAGULATION

Electrocoagulation refers to the deep destruction of malignant tumors in which a greater amperage is used, with more penetrating results. In its effect, this modality is

more intense than desiccation. The current is obtained by connecting two cords to the two terminals of a diathermy apparatus. A large inactive electrode is connected to one cord and applied adjacent to the area that we wish to destroy. The active electrode, or needle, would necessarily come from the other cord. With the current on, deep destruction takes place. Histologically, our cells completely lose their outline. Karyorrhexis and karyolysis set in, with thrombosis of the blood and lymph channels.

We can thus readily see how advantageous it would be to destroy a highly malignant growth, sealing the blood and lymph channels, as we gradually proceed in its destruction. The likelihood of metastasis then would become progressively less.

GASTRO-INTESTINAL MOTOR INSUFFICIENCY

In studying the motor phenomenon of the gastro-intestinal tract, it is essential to have x-ray films made of the entire system. This will always give us a clew, if any organic pathology, such as ulcer or cancer, is the cause of motor insufficiency. However, once organic pathology is ruled out, the cause for the functional disturbances must be ascertained.

In the study of the colon for motor insufficiency and stasis the barium enema is the best method. Radiographs made after a barium colon enema portray the true conditions existing in the entire colon, from the cecum to the sigmoid. When a case of constipation presents itself, it is essential to distinguish between the sluggish colon and the weakened, fatigued colon. In the former, the stimulus to work is absent, in the latter, muscular co-ordination. A patient who manifests the symptoms of a sluggish colon complains of digestive disturbances, infrequent, hard, and dry stools with a great deal of abdominal distress. A film taken 72 hours after the ingestion of a barium meal would still show stasis in the ascending and transverse colons. On the other hand, on injection, a barium colon enema would show no defects in course or outline of the colon, but a plate made after evacuation would show a major part of the enema to be retained. This is accounted for by the sluggishness in the muscular coats of the colon.

However, the patient with lack of muscular co-ordination in the colon, due to weakened and fatigued muscles, gives us the history of having loose stools of the dry and hard type. This patient also complains of distention and gas pains for which he has often resorted to cathartics and enemas, frequently with no results. He eventually becomes very nervous. In these patients, gastro-intestinal studies show a nervous colon. Six hours after ingestion of the barium, the head of the meal reaches the sigmoid, indicating a marked colonic hypermotility. After 24 hours, the entire meal is evacuated. A barium colon enema is seen to pass through the smooth colon with great speed. The cecum becomes greatly distended, due to lack of muscular tone; few, if any, haustral markings are noted. Finally, after evacuation, all the barium has left the colon. No resistance whatsoever is offered in its exit. The atonic condition is well borne out by films taken after the expulsion.

GASTRO-INTESTINAL TREATMENT

In the treatment of gastro-intestinal diseases, we must resort to surgery, if ulcer or malignancy exists. On the other hand, if localized muscular inability or dysfunction exists, especially in the colon, some mechanical action, such as diathermy or galvanism, should be instituted.

The restoration of the tone of sluggish muscles and nerves by hand manipulation and massage was in use long prior to the various electrical modalities of to-day.

BONE FRACTURES

In fracture of a bone, it is always essential to obtain good apposition and bony

union. However, after this is accomplished, we must then obtain a good functional result. It may, therefore, not alone be in the osseous result but in the functional impairment that physiotherapy is expedient.

Physiotherapy should not be instituted long after damage has been done. It should not be relied upon to rehabilitate cases functionally impaired long after several unsuccessful attempts for bony union have failed. Rather, it should be instituted from the very onset. First the surgeon should obtain the best approximation of the fragment ends possible; the final restoration and coordination of the various neuromuscular bundles belongs to the realm of physiotherapy. It is indeed sad to see an extremity markedly atrophied and fibrosed, with no muscular function, after a perfect bony union has resulted.

If it becomes necessary to immobilize an extremity or part of the body in a cast, as in a Whitman spica, windows should be cut into the cast and physical modalities applied in order, at the very start, to prevent atrophy of the nerves and muscles. In some locations it is advisable to split the cast and stimulate the muscles daily. Even in Pott's fracture, in order to stimulate the muscles around the joint, it is advisable to remove the plaster very early and to submerse the foot in the whirlpool bath.

Often one observes that functional restoration of a slight fracture about a shoulder joint becomes a difficult problem. This is, in all probability, due to the great amount of peri-articular infiltration and inflammatory limitation of motion, as well as pain as the sequelæ. Added to this is the adduction and immobilization caused by Jones' position, which virtually plasters and shrinks the nerve and muscle bundles together. More external rotation, and abduction maintained in place by a brace with windows over the deltoid muscle for treatments, would alleviate much suffering in the end. Therefore, early co-operation between the surgeon and the physiotherapist would certainly lead to better post-fracture functional results in the earliest possible time, eliminating the word "after-treatment" from the reports of the orthopedic department.

PHYSICAL THERAPY AS APPLIED TO GYNECOLOGY

Diathermy has been used with good results in many gynecologic clinics, not only in cases of pelvic infection but also in post-operative adhesions.

The abdominovaginal method is employed. Here we place our active electrode in the vagina, put a plate, our inactive electrode, over the abdomen, and use the d'Arsonval current for an allotted time, depending on the lesion we are treating. This method is often used in treating inflammatory diseases, Neisserian infections, and post-operative adhesions. For clearing up such cases as cervicitis and endocervicitis, we rely mainly on electrocoagulation, using a fine-pointed needle as our active electrode.

The part that heat plays in curing disease has long been known. We are familiar with the fact that body heat is a good culture medium for bacteria; any elevation from this temperature has a deterrent effect on bacterial growth. Furthermore, increased heat causes increased circulation, with an out-pouring of leukocytes and antitoxin and a resultant phagocytosis. General metabolism is also speeded up, and the weakened and diseased part under treatment is given further aid.

In treating gynecologic diseases by diathermy, the abdominovaginal method is the one of choice, due to the fact that most heat is generated at the point at which the pathway of resistance is less. An 8×10 electrode is placed over the lower abdomen and a vaginal electrode is inserted into the vagina posterior to the cervix. From 1,200 to 1,600 ma. are given, according to the tolerance of the patient.

CONTRA-INDICATIONS

There are certain definite contra-indications. Diathermy should never be used in the presence of an acute condition, especially if pus has not been evacuated. In cases in which ovarian cysts or tumors are present, the bipolar current is contra-indicated. It should never be used during menstruation, or if open blood vessels exist. It is, therefore, essential that one select proper cases for diathermy, as success or failure in choice determines the prognosis of the patient.

A word might be said also of the use of galvanism in gynecologic diseases. If we bear in mind that the position pole tends to shrink tissue, we can readily see the result of applying this pole to a large, boggy, edematous uterus. Galvanocautery is also used in the treatment of endocervicitis.

ACTINOTHERAPY AND ITS PHYSICAL APPLICATIONS

The field of dermatology has been enlarged four-fold since the advent of electro- and actinotherapy. Not only has ultra-violet radiation played an important part in the treatment of skin conditions, but infra-red and x-rays, electrodesiccation, and coagulation have all come to the aid of the dermatologist. The rôle that x-ray therapy plays in skin infections is too well known to need elaboration. The physical agencies used most in skin conditions are the quartz mercury vapor lamp, either air- or water-cooled, electrosurgery, and x-ray therapy.

The effects of irradiation with the air-cooled quartz lamp are not only bactericidal and parasiticidal, but intensive dosages cause desquamation. If greater penetration of ultra-violet is desired, the water-cooled quartz vapor lamp may be used. Many skin conditions, as epidermophytosis, tinea, versicolor, erysipelas, burns, and infected wounds, give good results under proper treatment. We find psoriasis highly resistant to any form of ultra-violet therapy; here x-rays are efficacious.

To reiterate, physical therapy, with its numerous modalities, will quickly come into use as soon as its beneficial results and methods of application become better known to physicians.

CONGENITAL NON-ROTATION OF THE COLON[1]

WITH CASE REPORT

By MEYER GOLOB, M.D., New York

THIS case of congenital non-rotation of the colon is believed to be of interest, because it represents a rare anomaly, reports of which in the literature are extremely few.

It is not altogether easy to find concise descriptions of the normal positions of the colon in all its parts; neither have we access to comprehensive studies of the anomalies in the location of the colon which are met with in surgical practice, without exhaustive research of medical journals over a term of years. The rational explanation of this lack is undoubtedly the characteristic absence of clinical symptoms accompanying such anomalies, which are for the most part discovered accidentally at operation or post-mortem. As von Bergmann has said, "Abnormalities do not, of themselves, produce symptoms, but lead to mistakes in diagnosis."

However, with the more facile handling of abdominal section of late years, due in no small part to the superlative advantages

[1]Read before the Staff and Faculty Meeting of the New York Homeopathic Medical College and Flower Hospital, March 8, 1933.

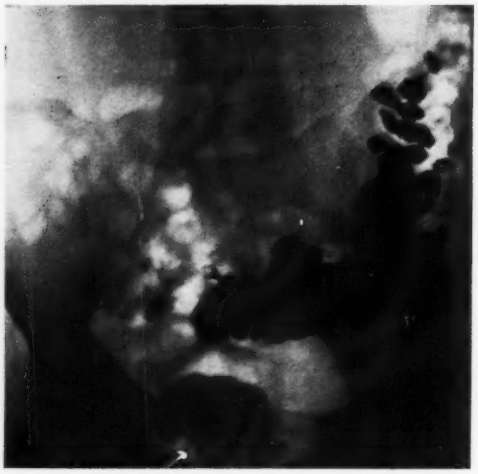

Fig. 1. Roentgenogram taken nine hours after the ingestion of the barium meal. Arrow shows shadow seemingly in the rectum. Digital examination revealed a spacious and empty ampulla recti.

afforded by spinal anesthesia, and with the recent enormous increase in explorative and corrective laparotomies, anomaly in the position of the colon is a subject of not a little importance to surgeons.

It is quite possible that, with our increasing use of roentgenography diagnostically and with a more lively interest in reporting these cases, non-rotation of the colon will be found to occur much more frequently than has been thought.

Kantor (1), collaborating with others, recently reported his study of the common anomalies of the duodenum and colon over a period of eight years. He bases his survey on a series of 3,000 private patients with digestive disorders, practically three-fifths of whom were examined by test meals and roentgen surveys in addition to other routine measures. It is his observation that, clinically, anomalies fall into three classes: (1) those incompatible with life, such as complete obstruction; (2) those compatible with life but not with robust health, such as excessive visceroptosis, and (3) those which, under favorable circumstances, do not appear to have any detrimental influence on health. In the latter—and he thinks it a general tendency—the body as a whole successfully compensates for the anomaly, which remains undiscovered unless the compensatory mechanism breaks down under the influence of mechanical, infective, or asthenic handicaps.

Functional instability as in the neuroses is a contributing factor leading to the dénouement of an occult colonic anomaly. This coincides with the pathologic picture of the case herewith presented. My patient had had an anxiety neurosis for some months, with gastro-intestinal symptoms. Routine roentgenography disclosed a marked gastroptosis and, incidentally, an enteric anomaly consisting of non-rotation of the proximal colon.

Kantor found that the most common congenital anomalies of the colon and duodenum are the so-called duodenal bands known variously as veils, membranes, or adhesions in the upper right quadrant; the redundant, or excessively long, colon, giving an appearance of more than one colon; high cecum, or arrested embryonic development so that the adult cecum occupies a position nearer the liver than is normal, with a shortened ascending colon or none at all, and, finally, the abnormally low cecum, due probably to embryonic hyperdescent.

Much more rare, at least insofar as reports have been published, is the anomaly due to congenital non-rotation of the proximal colon.

Hecker, Grunwald, and Kuhlmann (2) reported a case and made a survey of this anomaly in 1926, their references covering the period from 1815 to 1920. Their bibliography (30 references), while it cannot be considered a complete connotation of reports, is comprehensive enough to justify one in basing thereupon an opinion concerning the rarity of the anomaly. These writers found that the medical literature contains only about forty cases of sinistrocolia or dextrocolia; that is, the entire colon either

on the right or on the left of the abdominal cavity, or, more frequently, in a position resulting from the non-descent of the cecum. Their important clinical observation is that diagnostic ignorance of the existence of an anomaly and, also, of the types of anomalies the surgeon may encounter unexpectedly upon opening the abdomen, is conducive to fatal surgical accident. Hence they feel that a more comprehensive study is not only a matter of erudite interest to anatomists and embryologists but of practical significance to the surgeon.

Before I report my own case of the rare intestinal anomaly known as congenital non-rotation of the colon, it will clarify our knowledge of the subject to recall the manner in which the digestive tract develops in the fetus.

The primitive alimentary canal is a straight vertical tube, held to the spine by a fold of peritoneum, the stomach first appearing on this tube as an enlargement. The tube below the stomach then grows in the following manner: That portion leading out of the stomach grows with comparative rapidity to form the lengthy coiled small intestine, while the distal portion of the tube grows much more slowly, retains its peritoneal connection with the spine, and eventually becomes the descending colon, the sigmoid flexure, and a partial left segment of the transverse colon.

Now let us imagine a watch laid flat upon the abdomen, with the dial facing outwards. As the large intestine continues to grow, the end which will become the cecum elongates in a course counter-clockwise, the rudimentary cecum pushing farther and farther across the abdomen to the right until it lies at the right under the liver. Then it describes a turn downward, following a descending course until it is fixed in its normal adult position relative to the right iliac fossa. This growth movement, counter-clockwise, is the so-called normal embryonic rotation of the large colon.

Fig. 2. Barium suspension enema before evacuation. Arrows indicate physiologic direction of the parts of the colon; *(a)* Terminal loops of the ileum in place of the cecum and ascendens.

As Hecker, Grunwald, and Kuhlmann have explained, it is reasonable to believe that development of the large colon can be arrested in fetal life at various stages of growth. The purpose of their study of the reported cases of such anomalies was to formulate, if possible, a usable and easily recognizable classification of the degrees of non-rotation commonly found in these anomalies.

It will be pertinent to follow briefly their classification. They divide malpositions of the large colon into three main divisions: (1) dystopias resulting from faults of normal rotation, counter-clockwise; (2) dystopias resulting from an anomalous *inverse* embryonic rotation *clockwise* instead of the usual counter-clockwise rotation, and (3) dystopias resulting from insufficient fixation of colonic flexures. According to their classification, it will help the surgeon diagnostically to recall that arrest of growth may occur at any degree of the growth.

Fig. 3. Same as Figure 2. Arrows indicate retrograde direction of the colonic parts; *(a)* Terminal loops of the ileum.

Thus in the first group—the malpositions persisting in normal embryonic rotation counter-clockwise—stoppage of growth may occur so that the adult state may present any one of the following anomalies. *(a)* No growth of rotation initiated at all, so that the large intestine is in a plane posterior to the small intestine. *(b)* Normal rotation counter-clockwise initiated but growth arrested within the first 90° of rotation, with the small intestine to the right and the large colon to the left. The co-authors of this classification call this degree of arrested development "sinistrocolia of the first degree of normal rotation." *(c)* Growth arrested after 180° of normal counter-clockwise rotation. This they describe as showing the colon still on the left but the ileocecal region approximating the midline or umbilical line. This degree of arrest they call "sinistrocolia of the second degree of normal rotation." *(d)* Arrest of growth after 270° of rotation, with the cecum in a subhepatic position but undescended. Called "dystopia of the third degree of normal rotation." *(e)* Various degrees of arrest in the embryonic descent of the cecum from a subhepatic position to its normal adult position on the right side relative to the iliac fossa.

In the second main classification—or malpositions resulting from an anomalous *inverse* embryonic rotation, that is, clockwise instead of the normal counter-clockwise rotation—growth may likewise be arrested in various stages, which these authors classify as *(a)* between 0 and 90°, resulting in their so-called adult "dextrocolia of the first degree of inverse rotation"; *(b)* between 90° and 180°, resulting in their so-called adult "dextrocolia of the second degree of inverse rotation"; *(c)* between 180° and 270°, resulting in their so-called adult "dextrocolia of the third degree of inverse rotation"; *(d)* various stages of insufficient descent of the cecum on the left side in inverse rotation.

I feel that these investigators, by presenting a reasonable and clearly classified diagnostic scheme, have made a worthwhile contribution to our scant published information on the subject of the various anatomical aspects of this condition.

REPORT OF CASE

Female, aged 43, married, multipara, negative marital and menstrual history, was referred to me by Dr. Louis Newton. Previous personal history was irrelevant except for an allergic tendency, which manifested itself in a "bronchial asthma" that had lasted for one year at the age of 33, and had recurred recently, continuing for one month. Her present illness was of five months' duration, with the stigmata of an anxiety neurosis, expressing itself as fear of approaching mental aberration.

The physical findings except for the symptoms of the neurosis and a loss of weight were negative. The symptomatology refer-

able to the gastro-enteric tract was non-inferential. However, a definite hypochlorhydria in a multipara with a subicteric facies was suggestive of biliary tract derangement. This potential diagnosis was refuted by cholecystography. A proctoscopic examination revealed no abnormality. The neurologic findings were negative.

Combined roentgenoscopy and roentgenography of the gastro-intestinal canal were negative except for a marked gastroptosis, with an apparent non-rotation of the proximal colon. The oral method of examination with barium meal and the barium suspension enema method gave a picture of failure of the proximal colon to rotate from the left of the vertebral column to the right and the ileocecal junction was apparently on the outer aspect of the cecum instead of the inner, the terminal ileum occupying the space usually occupied by the cecum and the ascending colon.

Under the fluoroscope a dense shadow was seen in the region of the rectum not accessible to palpation. It conveyed to the examiner the impression of being in reach by a rectal digital examination. However, the rectal examination showed the ampulla empty. Deductively it was reasonable to conclude that the dense shadow was in the cecum.

The interesting features in this case are a negative history referable to the gastro-intestinal canal, an anxiety neurosis of five months' duration, detection of an intestinal anomaly through routine roentgenologic study, and successful amelioration of the pathologic manifestations following institution of psychotherapeutic methods for relief of the functional neurosis.

Developmental arrest of any organ can be explained only by a knowledge of embryology, a lengthy discussion of which does not come within the scope of this paper. So far as the large colon is concerned, as Carman (3) has written, "Arrest of developmental migration may result in a high-placed cecum, or the entire colon may still lie to the left of the vertebral column—so-called non-rotation. By failure of the cecum and ascending colon to rotate on their long axes, the ileocolic juncture may be found on the outer aspect of the cecum, instead of the inner."

The paucity of symptoms referable to the gastro-intestinal tract in these anomalies, due probably to some compensatory mechanism, explains the usual failure to diagnose the anomaly readily, since the symptoms seldom seem to warrant roentgenologic examination. However, when such patients do present symptoms of a digestive aberration, it is perhaps in some instances due to tossing and churning of the filled colon toward the right abdomen, thereby exerting pressure on the pyloro-duodenal region and giving rise to gastro-intestinal distress. Absence of a bowel syndrome, in spite of crowding of the colon in the left abdomen, may be explained by the fact that there is less space in these instances for the colonic content to travel in its transit to the distal colon. In the case under discussion, the gastro-intestinal tract was singularly free from symptoms and the x-ray study was done merely as a means of reassuring the patient of the absence of an organic etiology for her neurotic stigmata. While such congenital anomalies may not manifest themselves clinically for many years, they afford a link of least resistance in the bodily economy, predisposing to precipitation of pathology from various causes. Left-sided appendicitis is a frequent dénouement of congenital non-rotation of the proximal colon. With such a probability in mind, the surgeon would not be inclined to make "a button-hole" right rectus incision, but would prefer to make an abdominal entrance of sufficient size to allow him to explore the abdominal cavity with the whole hand.

It is not my present purpose to quote extensively the cases which have been reported

in the literature. However, the several which follow are pertinent as indicative of the varied symptomatology during the diagnosis or treatment of which the presence of the anomaly may be discovered.

Fig. 4. After evacuation, showing entire colon to the left of the vertebral column.

Mayo (4), in a series of five cases operated on, three for appendicitis and two for acute abscess, found the anomaly of "left-sided appendicitis" due to congenital non-rotation of the colon. Only one of these was correctly diagnosed from the physical signs and the x-ray before operation.

Delatour (5) reported one case of left-sided appendicitis, undiagnosed until after an exploratory laparotomy was made. A gangrenous appendix was located to the left of the midline, with a subsequent history of fatal peritonitis. In this case, there was a short transverse colon, with the ascending colon crossing the abdomen obliquely, the cecum being entirely to the left of the spine. In another of Delatour's cases, there were intestinal symptoms of constipation, with attacks of diarrhea and recurrent abdominal pains. Following an exacerbation of pain a diagnosis of left-sided appendicitis was made. On operation, the ascending colon was found in the left half of the abdomen, passing directly up and parallel to the descending colon, with an inflamed and swollen appendix. Delatour's third case, brought to operation because of an erroneously diagnosed cholecystitis, was found to be one of appendicitis, the anomaly being an arrest of embryonal growth of the colon, with cecum undescended from its embryonic subhepatic position.

In Roberts' case (6), the symptomatology suggested a syndrome of reversed peristalsis of twelve years' duration. Many examinations had failed to reveal any tenderness in the right iliac fossa. Non-rotation of the colon was eventually diagnosed from the roentgenogram. I concur with Roberts' con-

clusion from his experience with this case that "the position of the intestinal tract cannot be made out with any degree of certainty by ordinary methods of examination, and during abdominal operation dangerous delay in finding the cecum and appendix may result unless the anomaly has been demonstrated by a previous roentgen examination."

Grove's case (7) is pertinent because of the unusual symptomatology: stomach trouble dating back to infancy and frequent attacks of cramps in the left abdomen, associated with diarrhea. The x-ray disclosed that the terminal ileum seemed to be emptying into the cecum from the right, or outer, side instead of at the inner surface of the cecum. This case is unusually interesting because it demonstrates a relationship between an adult digestive inferiority and a congenital anomaly, with treatment directed toward the persistent diarrhea. Eventually operative intervention disclosed the anomaly, which when corrected surgically relieved the symptomatology.

SUMMARY

1. Though congenital anomalies of the colon may be symptomless for years, they are a point of least resistance which, under unfavorable circumstances, will undoubtedly give rise to trouble.

2. Undiagnosed pre-operatively, they predispose to surgical accident.

3. Roentgenographic diagnosis pre-operatively is indicated for chronic abdominal conditions as a precautionary measure to rule out congenital malpositions.

4. A better knowledge of colonic congenital malpositions should be sought as an aid to surgery.

5. A case report is given of the rarely reported malposition known as congenital non-rotation of the colon.

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THE THORACIC SURGEON AND HIS RADIOLOGICAL CO-WORKER[1]

By WILLIAM A. HUDSON, M.D., F.A.C.S., DETROIT, MICHIGAN

THE thoracic surgeon has at his command numerous methods of investigation which enable him to obtain information of value. He is able to inspect the outside and he may auscultate and percuss the chest as means of determining some of the changes within it, or he may inspect the inside of the trachea, the bronchi, and the esophagus through a bronchoscope or esophagoscope as an additional method of obtaining information. After employing any or all of these procedures, there still remains much of the thoracic content about which he is more or less in the dark. However, an additional source may be drawn upon for information and that is radiology. The radiologist is usually, and should be, called upon before resorting to endoscopy.

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

The best observers overlook warning symptoms or signs of definite disease at times. In our clinics, where all the recognized surgical procedures applied in the practice of thoracic surgery are constantly being used, where between 2,000 and 2,400 endoscopic examinations alone are performed yearly, our experiences have been such that we no longer feel justified in omitting from our routine examination any investigation that will serve to check our findings. We are so thoroughly convinced of the value of the radiologist and of our dependence upon him for information and counsel in the study of thoracic lesions that we are constantly and continually haunting his laboratory.

At the risk of becoming boresome we would like to review briefly the procedures through which we go during the examination of our patients. Following the history taking and physical examination, and after the routine laboratory work has been carried out, we *take*, and I do not mean *send*, the patient to the roentgen-ray laboratory. We insist upon being present at the time roentgen-ray film records are made and a fluoroscopic study of the chest is carried out in all projections. The roentgenologist is in a position to point out to us the ronetgenologic features both from the film and the fluoroscopic studies as they are observed, thereby giving us a much clearer conception of the case from a roentgenologic standpoint than any word-picture could do. At the same time, the two of us are in a position to correlate the history and physical and laboratory findings with these roentgen-ray studies to the patient's advantage. Certainly any diagnosis arrived at thus will be much more likely to be correct, because of the consideration which each of us will be able to give all the findings, than would a diagnosis reached separately and independently. I know that I have profited greatly by this close relationship with the radiologist, while I hope that my radiological friends may have cause to feel that they too have obtained something of value from the association. The few experiences mentioned throughout this paper are selected from the many I have had with radiologists.

The cry to-day is for early diagnosis, especially in regard to tuberculosis and cancer. An early tuberculous lesion or even a large cavity of the lung may be entirely overlooked if one permits oneself to hurry through an examination. For example, take the case of a woman who had spat up a considerable amount of blood without warning symptoms. She had undergone previously an operation for removal of an adenoma of the thyroid, left, with an entirely satisfactory recovery. Physical examination revealed one or two râles at the left apex anteriorly and near the sternum. Roentgen-ray studies showed a small area of increased density at the same point. It was thought this change might be accounted for by the pressure of the adenoma on the apical pleura, with a deposit of scar tissue. There was no sputum.

The question arose, however, as to whether there was a newgrowth or a tuberculous process present in the left lung or if, possibly, the blood came from the food passages. Bronchoscopy was performed and the blood was found to come from the left upper lobe bronchus. No evidence of malignancy was encountered and the opinion was then given that the lesion was a tuberculous one of the left lung. This was later proven by guinea pig inoculation and by smear from the secretion. The patient made a satisfactory recovery under appropriate treatment.

As a second illustration we might cite the case of a white male, 38 years of age, who complained of cough and of a pain in his left side, together with loss of weight. He had been through one of our largest institutions, where no record of any findings of serious consequence was made. Within three weeks of that time, physical examina-

tion revealed a few râles in the central left lung field, posteriorly, and some increase in the pitch of the breath sounds over the same area. The sputum contained tubercle bacilli. Roentgen-ray studies revealed a large cavity in the mid-portion of the left lung near the posterior lateral chest wall. Under collapse therapy, closure of the cavity was obtained.

The first case illustrates the value of endoscopy and history, even in the absence of convincing roentgen-ray findings, while the second illustrates the ease with which a large pulmonary cavity may be overlooked when roentgen-ray studies are omitted.

Frequent recourse to the roentgen ray is necessary in the treatment of pulmonary tuberculosis by collapse therapy. One encounters from time to time men who attempt to administer pneumothorax with no check as to the degree of collapse established other than their interpretation of the physical signs, yet we have found it impossible to estimate satisfactorily without the aid of roentgen-ray studies. Fluoroscopy should be resorted to at frequent intervals, particular attention being given to the following:

(1) The degree of collapse, especially of the diseased area;

(2) The presence of adhesions which may interfere with the efficacy of the collapse;

(3) The presence of fluid.

Such observations serve as means of protecting the patient against the establishment of too great a collapse, also of selecting cases suitable for the various operations of pneumolysis from that general group in which adhesions interfere with collapse. Finally, one must have the roentgen-ray confirmation after a pneumolysis has been performed, to establish the fact that an entirely satisfactory result has been obtained.

In the same manner, following operations upon the phrenic nerve, it is essential that all patients be subjected to fluoroscopic study of the diaphragmatic function, preferably immediately after the completion of the operation. At such an examination, if the surgeon and the radiologist observe a fixed hemi-diaphragm, or if the affected hemi-diaphragm is seen to act in a manner opposite to normal, they may rest assured that the desired paralysis has been obtained. On the other hand, should any portion of the hemi-diaphragm under investigation show evidence of normal movement, they may rest assured that at least some of the phrenic fibers to that portion of the diaphragm have been overlooked. Roentgen-ray films do not show this reverse or see-saw, action so readily and it is for this reason that resort should be had to fluoroscopy.

The success obtained in the treatment of pulmonary tuberculosis by the more radical operations, that is, thoracoplasties of different types, is to a large extent due to the roentgen-ray evidence collected during the selection of the patients for these operations, and in part to the free use of roentgen-ray studies as a means of determining the degree of collapse obtained following each stage during the operative procedures.

It is difficult to make a diagnosis in a case of early cancer of the lung. As we stated earlier, the roentgenologist should be called upon to study the patient in company with the thoracic surgeon before recourse is had to endoscopy. This certainly applies in the case of suspected malignancy of the tracheobronchial tree. *An apparently negative roentgen-ray study should not, however, interfere with the carrying out of an endoscopic examination in a patient whose symptoms suggest some pulmonary lesion.*

For instance, a white male, 31 years of age, complained of blood-spitting and of being underweight, the former having persisted at intervals over a period of from three and one-half to four years. Numerous physical examinations and roentgen-ray

studies were said to show nothing wrong in the lung fields. Bronchoscopic examination revealed a small nodular mass in the orifice of a posterior medial division of the left lower lobe bronchus and adjacent to this mass was a small ulcerated area. Active bleeding was present from this area at the time. The nodular mass was removed and a microscopic report of adenocarcinoma was made. With the implanation of radium in the bronchus and with the application of deep roentgen therapy, the patient has remained symptom-free for three and one-half years. Bronchoscopic inspection shows no evidence of ulceration or of any mass, and roentgen studies remain free of evidence of newgrowth.

Contrast the above picture with that of a white male, 62 years of age, who complained of shortness of breath and cough over an interval of from six to eight months. He was treated with cough mixtures and tonics and finally a roentgen examination was made. These studies revealed a large area of increased density in the mid-left lung field, in the center of which was an area of decreased density. Because of the age of the patient endoscopic examination was suggested by the roentgenologist. Bronchoscopic studies revealed a fungating mass near the orifice of the left lower lobe bronchus, and that there was considerable pus present. Our impression was that the lesion was a carcinomatous one. Biopsy revealed a squamous-cell carcinoma, and a final diagnosis of squamous-cell carcinoma of the left lung, with cavitation and infection, was made, and confirmed at postmortem. It certainly was not the fault of the roentgenologist that an earlier diagnosis was not made in this case, but the two cases above illustrate one of the points we wish to bring out, namely, any unexplained cough or blood-spitting should lead the roentgenologist to suggest to the clinician the advisability of an endoscopic examination even in the absence of positive roentgen findings.

In an unpublished paper on lung abscess, we have tried to bring out in detail many of the important facts that have developed through our experiences in dealing with suppurative lesions of the lung. For brevity's sake I will mention only one or two of these points. We have noted that the roentgen evidence of lung abscess may vary from a small area of increased density in some portion of a lung field to complete involvement of areas corresponding with one or more lobes of the lung, with evidence of cavitation and fluid level. We are aware of the fact that many roentgenologists do not feel justified in making a diagnosis of lung abscess until such time as they are able to demonstrate a definite cavity in the lung.

In this study we have used the term "impending abscess," especially in relationship to certain types of early changes, and have stated that it is highly desirable for one to make a diagnosis of an impending lung abscess, thereby enabling the clinician to call upon the thoracic surgeon to institute proper treatment rather than to delay until a fully developed cavity with fluid level has formed. In case of a diagnosis of impending abscess, treatment may be instituted early and the period of convalescence thereby shortened, whereas, when a diagnosis is delayed the period of convalescence is usually prolonged.

"It is not an everyday occurrence for the general practitioner to encounter a lung abscess and one must not censure him too severely if he does not resort to endoscopy or some conservative method of active treatment at an early date. On the other hand, the roentgenologist sees numerous cases and if he has acquainted himself with the progress of other cases that have passed through his hands, he can with all sincerity recommend intervention or at least consultation as to the advisability of intervention."

In the beginning of this paper we emphasized the fact that a history was taken before other procedures were carried out

Later, we stated that an apparently negative roentgen study should not interfere with an endoscopic examination when the history seems to indicate the presence of a definite but unexplained pulmonary lesion. We would now like to point out that *in the absence of a definite history or of physical findings, positive findings in the roentgen-ray studies must not be disregarded and should lead to endoscopy or other confirmatory procedures.*

To illustrate, a white male, 47 years of age, had been subject for many years to what had been interpreted as chronic bronchitis, and had suffered ten months previously from pneumonia complicated by an empyema. The latter had been drained but the drainage tract refused to close; subsequently proper drainage was re-established. The surgeon was convinced that there was present something of an unusual nature which prevented the closure of the empyema drainage tract, and roentgen-ray studies were made. They revealed a shadow in the bronchial tree of the corresponding lung field that closely resembled the shadow of the root of a tooth. The patient was questioned by the surgeon, especially in regard to any operative procedures, including extractions, all of which were repeatedly denied. On the basis of this negative history, even in the presence of such a definite roentgen finding, endoscopy was not resorted to. Later, following manipulation of the bronchi and the instillation of oil by the retrograde method, the root of a tooth was expelled. The patient then recalled a previous extraction—more than nine years past. This case illustrates the fallacy of placing too much confidence in a negative history in the presence of positive roentgen-ray findings.

Or, again, we might illustrate our point through the case of a boy, 11 years, 6 months, of age, who gave a history of cough, with foul sputum, over a period of seven and one-half years. During this time he had undergone numerous examinations, including roentgen-ray studies. He had been assured that he did not have tuberculosis, but did have an infection in the base of his right lung. He had taken various cough syrups, without relief. On questioning the mother we learned that when the cough developed the symptoms led to a diagnosis of whooping cough. While the boy was supposed to have recovered from that, his cough never did leave him. Our examination revealed evidence of a right basal infection, a temperature of 103°, a severe cough, with foul sputum, and an increased white blood cell count. We started our study with the idea of trying to find a cause for this cough. Roentgen studies were made, using the routine technic for chest films. These films showed a shadow of great density over the right base, extending up to the angle of the scapula. Though no distinctive marking could be seen in this area, we were not satisfied with our information. Next, with the aid of the roentgenologist, a fluoroscopic study was made. A shadow of slightly greater density than the adjacent structure was noted near the right hilum. Additional roentgen-ray films were made of sufficient penetration — somewhat greater than ordinarily used in studies of the spine —to reveal the area of great density at the right base. When we came to study these new films we had before us the explanation, that is, there was a foreign body near the right hilum—the shadow resembled a wood screw. Bronchoscopy was then performed and a screw, coated with rust, was removed. The patient made a complete and rapid recovery. This particular case serves to emphasize not only the importance of looking in the history for a causal factor of the ailment, but it also illustrates a point that Dr. Rollin Stevens has often mentioned, namely, that "no roentgen-ray film is too good from which to make a diagnosis."

From a technical standpoint a film may be apparently perfect, but because of the particular circumstances surrounding the case it may be worthless.

Dr. Chevalier Jackson and his associates have so frequently spoken of the importance of two-way fluoroscopy as an aid in the removal of foreign bodies, that we need only remind you of its great value and suggest that the thoracic surgeon and radiologist will be able to work together to better advantage at such times as two-way fluoroscopy is needed, if they have had intimate contact in the fluoroscopic room during their routine work.

To illustrate, a white female, 19 years of age, was subject to frequent attacks of malaise and temperature. Repeated physical examinations were reported as being entirely negative. Studies of the urinary tract revealed nothing abnormal. Roentgen-ray studies, including a supraglottic lipiodol injection of the chest, added no diagnostic information. Because of a slight cough, bronchoscopic examination was done and the orifice of one secondary bronchus was seen to be inflamed. An aspirating tube was inserted into this bronchus from which pus was aspirated and replaced by 20 c.c. of lipiodol. The roentgen studies were then repeated, revealing a triangular area at the right base filled with the lipiodol. At operation an old encapsulated empyema was drained, and the patient's symptoms were relieved. This case is cited to bring out the fact that at times it is necessary to resort to special methods of using a contrast medium in order to obtain the most satisfactory information from a roentgen study.

We might cite one other instance, that of a white female, 38 years of age, who had swallowed lye at the age of two years and had been treated by dilatation of the esophagus. She had passed 36 years of her life with practically no distress, though she did find it necessary to eat slowly and to chew her food thoroughly. Twenty-four hours previous to the time we saw her she had choked while eating, and following this accident no food would pass into the stomach and she felt a definite discomfort in the lower esophagus. Saliva was not drooling from her mouth and she could take small quantities of fluids. An esophagoscopy had been attempted, but the stomach had not been entered with the esophagoscope, because it had been feared that the scarred esophageal wall might be torn. The question came up as to whether or not any food particle had lodged or whether the patient, who was of a nervous temperament, imagined the obstruction. A barium mixture was given, following which fluoroscopic and roentgenographic studies revealed a fairly normal lumen throughout the upper two-thirds of the esophagus, but the lower third was narrow and obstructed—in fact, one could see a splitting of the barium column at an obstruction, suggestive of a foreign body. Esophagoscopy was performed and a piece of meat was removed, with relief to the patient.

The many articles appearing in the literature on the subject of contrast media and their use in roentgen-ray studies signify the great value of the various media. Contrast media lose none of their importance when used in studies of thoracic diseases. In this field also the close co-operation of the thoracic surgeon with the roentgenologist is an important factor.

DEPTH DOSE CALCULATIONS FOR SUPER-VOLTAGE X-RAYS[1]

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Abstract.—Because of the tendency of those not actually working in this field to assume that raising x-ray tube voltages from 200 to 2,000 kilovolts (2 million volts) will give an increase in penetration and depth dose comparable to that brought about by the change from 20 to 200 K.V., calculations were made on the basis of existing published data (1931) to determine roughly the gain in depth dose to be expected with super-voltage tubes. Important factors are the following: (1) Most of the x-rays emitted by any tube have a "hardness" (voltage equivalent) corresponding to less than half of the voltage of the electrons striking the target; (2) lead is the best available filter for very high voltage x-rays, but since it absorbs 2,000 K.V. (monochromatic) radiation nearly as much as 600 K.V. radiation, the radiation from a 2,000 K.V. target heavily filtered by lead will contain more x-rays of voltage equivalent under 1,000 K.V. than above 1,000 K.V.; (3) the penetrating power of 2,000 K.V. (monochromatic) x-rays in water (tissue) is not greatly in excess of that of 600 K.V. x-rays.

Making approximate corrections for the increase in intensity at various depths due to scattering, from data on radium gamma-rays (Memorial Hospital radium "bomb"), the 10-cm. depth dose of a 2,000 K.V. tube heavily filtered by lead is calculated to be 50 per cent of the skin dose, for a skin-target distance of 50 centimeters. Utilizing the inverse square law, the 10-cm. depth dose of a 200 K.V. tube with ordinary filtering can be raised from 40 to 48 per cent of the skin dose by changing the skin-target distance from 50 to 100 cm. (the power input to the target would have to be increased four times for the same exposure times, of course). Thus, although the proportion of the *primary* radiation which reaches the depth of 10 cm. is very different in the two cases, the actual dosage being by effectively much "harder" radiation with the 2,000 K.V. tube, no extreme gain in depth dose is to be expected by using very high voltage tubes (unless intense atomic nucleus x-rays are excited, a phenomenon not to date discovered nor expected). It is emphasized that "depth dose" in this connection does not represent radiant energy flux nor energy absorbed from the beam, but the ordinary usage of the term to represent the empirical reading of a good small chamber ionization meter. Biologic effects may differ widely for the same depth dose at two widely different values of average "hardness" or voltage equivalent of radiation, hence *no biologic conclusions are to be drawn from the calculations outlined.* The writer very strongly takes the position that only careful and extended experimental tests with very high voltage tubes can determine their biologic and therapeutic value.

INTRODUCTION

It is desired to calculate approximate water phantom depth dose curves which will apply for x-ray tubes operated at voltages above 500 kilovolts. Physical laboratory measurements long since established the approximate monochromatic absorption coefficients for water, and it may be assumed that these will apply well enough also for biologic tissue, which is largely water, with the balance of the atoms present having approximately the same average atomic number as water. Corrections at various depths due to scattering can be obtained approximately from published water phantom measurements with the Memorial Hospital radium pack ("bomb"). Lead has the highest atomic number of all non-radio-active ele-

[1]Technical summary of a paper presented Dec. 1, 1931, before the Radiological Society of North America at St. Louis.

ments, and is consequently the best available filter. Its monochromatic absorption coefficients for various wave lengths have been measured and are in the literature. The exact law governing the spectral energy distribution to be expected from an x-ray target at various high voltages is not known. All measurements so far made, however (in the ordinary x-ray region) indicate that the intensity from any target is a maximum at the lowest frequencies, decreasing almost linearly to zero intensity at exactly the "quantum limit" corresponding to the (uniform) energy of the electrons striking the target. From these measurements it also appears that the total energy emitted as x-rays with various applied (high) voltages may be expected to lie between the limits (1) x-ray efficiency proportional to voltage, and (2) x-ray efficiency constant for all voltages. The exact shape and magnitude of the spectral energy distribution curves will not be important to our calculations. From these published data it is, therefore, possible to obtain an approximate idea of the depth dose curves to be expected at various high voltages. Since the "hardness" of the radiation at various depths will differ greatly with the tube voltage, even though the depth dose remains relatively constant, *no conclusions can be drawn from these calculations as to the relative biologic effects to be expected with very high tube voltages.* Because of possible misunderstandings on this point, the writer has hesitated for a long time before agreeing to publish these calculations.[2]

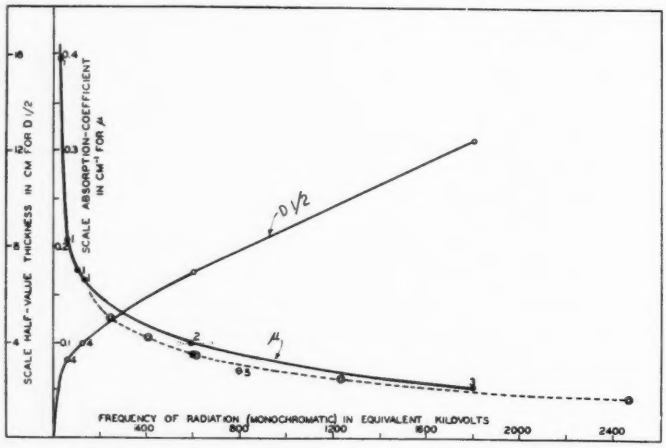

Fig. 1. Monochromatic absorption coefficients for water. [Points 1 after Richtmyer; points 2 and 3 after Kohlrausch, μ_1 and μ_2 (radium); points 4 after Kirchner; double circles after Klein-Nishina formula, and square 5 after Neukirken-Gray (0.26-cm. lead).]

SUMMARY OF CALCULATIONS

The monochromatic absorption coefficients as measured for water are shown in Figure 1. The curve marked "D ½" gives the half value thickness of water for various frequencies. Small differences in the values

[2]Note added in press: In a personal communication to the writer Dr. C. C. Lauritsen has given the results of some very interesting calculations to be published shortly. He considers (as above emphasized by the writer) that the "depth dose" readings of an ionization chamber are not a suitable criterion for making comparisons between medium and very high voltage radiations. He calculates instead the total *energy* (in the form of radiation) which can be *delivered* into the body for a given amount of *energy absorbed* in the skin. On this basis there is a distinct improvement with increased voltage, of the order of a factor of 1.8 in changing from 200 to 600 kilovolts tube voltage. He further points out that the depth dose at 15 and even 20 cm. is of importance, and here the harder radiations have a large advantage over 200-kilovolt x-rays. The writer originally presented and here records the empirical calculations of this paper only to indicate certain of the fundamental physical factors which are of importance to the problem.

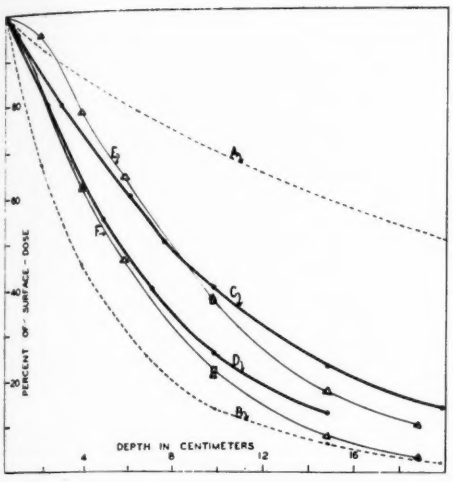

Fig. 2. Water phantom depth dose curves. [A = inverse square law only; B = theoretical depth dose without scatter, obtained by inverse square law plus absorption; C and D after Bachem (1923), 200 K.V., 1 mm. copper, for 20-cm. square portal and for 5-cm. square portal; E and F after Weatherwax (1930), 200 K.V., 0.5 mm. copper, 1 mm. aluminium, for 20-cm. diameter portal and for 5.5-cm. diameter portal.]

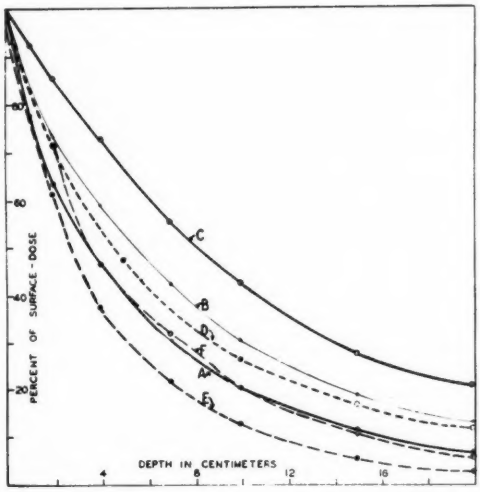

Fig. 3. Depth dose curves, Memorial Hospital radium pack. [A, B, and C = water phantom for 10-cm., for 15-cm., and for 20-cm. radium-skin distance; D = intensity in air (nearly inverse square); E and F = theoretical depth dose without scatter, for 10-cm. and for 20-cm. radium-skin distance.]

given by different observers are not important here. To indicate the importance of the correction for scattering, curves are given in Figure 2 for water phantom measurements with 200 K.V. tubes at 50-cm. skin-target distance. Curve A is the inverse square law decrease without absorption. Curve B is the depth dose to be expected without scattering, comprising the inverse square law and absorption (using absorption coefficient for 100 K.V. as an average hardness). Curves C and E are experimental water phantom measurements with 20-cm. portals, and Curves D and F the same with 5-cm. portals. The scatter correction is then the amount by which Curve B must be increased at each point to reach the experimental curve.

Similar water phantom depth dose curves[3] for the very much harder radiation from the Memorial Hospital radium pack ("bomb") are given in Figure 3. Curves A, B, C, and D are the experimental values, and Curves E and F are the expected values without scatter (inverse square and absorption, taking average hardness as 1,000 K.V.) which correspond to the experimental Curves A and C. The percentage increase of the dosage at various depths, due to scattering, is given in Figure 4 for two values of radium-skin distance. Because of the very large "portal" through which the rays strike the phantom for a radium-skin distance of 20 cm., and even for a distance of 10 cm., the scattering correction curve for a radium-skin distance of 10 cm. may be considered as a generous allowance for the dosage increase due to scattering which may be expected when using a high voltage tube giving radiation of equivalent hardness but with properly defined portals. From the absorption coefficients of Figure 1 and the inverse square law (Curve "$1/r^2$" of Fig. 5), the depth dose curves for *monochromatic* x-rays are then calculated for a skin-target distance of 50 cm. (Fig. 5). The dotted curves represent the calculated depth

[3] G. Failla, Am. Jour. Rontgenol. and Rad. Ther., 1928, XX, 128-141.

dose values with no scattering. The full curves are these dotted curves multiplied by the scattering correction marked "10 cm. Ra S D" in Figure 4.

We must next inquire as to the greatest

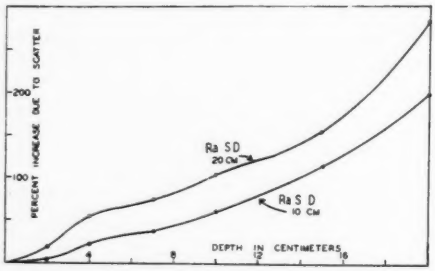

Fig. 4. Increase in depth dose due to scattering, Memorial Hospital radium pack.

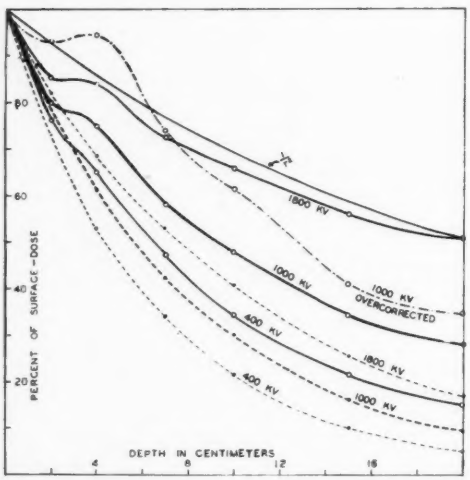

Fig. 5. Depth dose curves for monochromatic radiation at 50-cm. skin-target distance.

average hardness of the beam which we may expect to obtain from a heavily filtered super-voltage tube, operated, for example, on a 2-million-volt direct current source. Lead has the highest atomic number of any material available for a filter. It carries photo-electric absorption up to higher frequencies than lighter elements and consequently is the best material available for selectively filtering softer components out of the beam. Even so, it does not make an effective filter for frequencies higher than about 600 kilovolts equivalent. The absorption-coefficients for lead are given for various frequencies in Figure 6.

The remaining factor to be discussed is

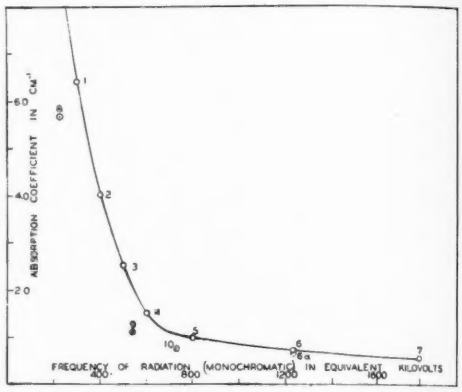

Fig. 6. Monochromatic absorption coefficients for lead. [1 and 2 after Hermann and Jaeger; 3 after Jaeger interpolated; 4 after Jaeger and Meyer and Schweidler; 5 after Gray-Skobelzyn-Kohlrausch (Ra, 0.35 cm. Pb); 6 after Gray-Ahmad (Ra, 1 cm. Pb); 7 after Gray-Kohlrausch; 8, 9, and after Compton (older estimates).]

that of the spectral energy-distribution to be expected from an x-ray target at various high voltages. From data in the region 40 to 140 K.V. Nicholas[4] concludes that the spectral energy distribution for the x-rays produced in the target by electrons of uniform velocity has the form shown in Figure 7, curve marked "100-K.V.-Nicholas" (this curve is the observed intensity distribution curve as shown in the jagged full line, corrected for absorption in the target), and that the total amount of energy converted into x-radiation lies between the limits (1) x-ray efficiency (output/input) proportional to the voltage, and (2) x-ray efficiency proportional to the square root of the voltage, and is probably near the latter. If we assume the first to be true (x-ray efficiency proportional to voltage), the slope of the distribution curve will be the same for all

[4]W. W. Nicholas, Bureau of Standards Jour. Res., 1930, V. 843-865.

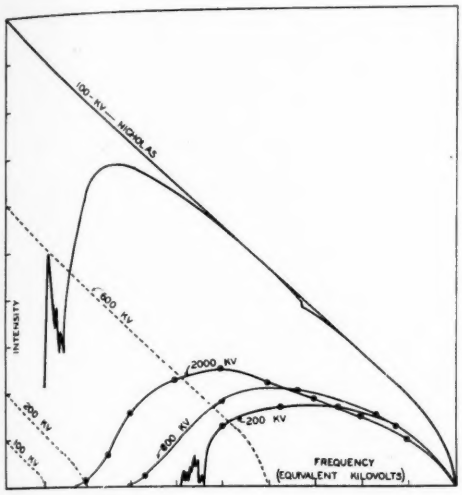

Fig. 7. Calculated spectral energy distributions for highly filtered x-rays, assuming x-ray efficiency proportional to voltage (see text for detailed explanation). [For a given value of current, dotted curves represent intensity distributions on actual frequency—(kilovolt-) scale—area under curves being proportional to V^2; curve "100 K.V.—Nicholas" represents intensity distribution at any voltage on percentage frequency scale—area under curve being constant; curves through plotted points represent intensity distributions in heavily filtered beams at voltages as marked.]

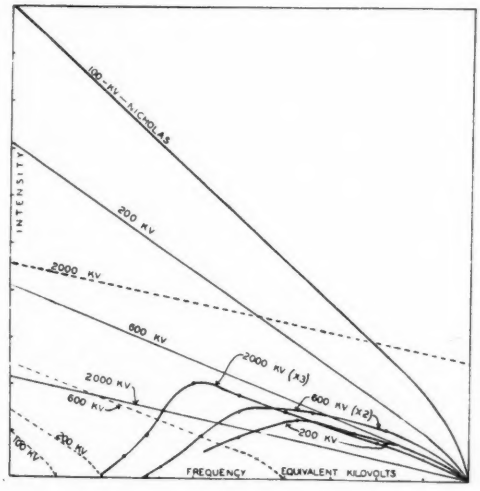

Fig. 8. Calculated spectral energy distributions for highly filtered x-rays, assuming x-ray efficiency proportional to $V^{1/2}$. [As in Figure 7, dotted curves for actual frequency scale—area proportional to $V^{3/2}$; full-line curves for percentage frequency scale—area proportional to $1/V^{1/2}$; curves through plotted points represent intensity distributions in heavily filtered beams at voltages as marked (multiplied by labeled factors for legibility).]

voltages on a given scale (area under curve proportional to total x-ray output). Hence if the curve marked "100-K.V.-Nicholas" represents the spectral distribution for 2,000 K.V., the curves for 600, 200, and 100 K.V. will be as shown by the dotted lines in Figure 7. Changing to a percentage frequency scale by magnifying both scales for each dotted curve, the curves for all voltages coincide with the curve marked "100-K.V.-Nicholas." With 2,000 K.V. on the tube, if we use a lead filter of such thickness as to give approximately 50 per cent transmission at 75 per cent of the quantum limit frequency, by applying the absorption coefficients of Figure 6 we obtain then a filtered beam of x-rays having a spectral energy distribution given by the curve marked "2,000-K.V." (Fig. 7). It is clear that the average "hardness" of such a beam corresponds to monochromatic radiation of a frequency equivalent to less than 1,000 kilovolts. The much greater extent to which 200 K.V. radiation may be "hardened" by a half value lead filter is indicated by a similarly calculated curve labeled "200 kilovolts." (The voltage scale is a percentage-of-full-voltage scale for the separate "filtered" curves, and the relative intensities are for points on the same curve, not for comparison between curves. The total energy radiated by a target with a given current is greater at 2,000 K.V. than at 200 K.V. in the ratio of the areas under the dotted curves, as above mentioned.) We may make similar calculations for the assumption that the x-ray efficiency is proportional to the square root of the voltage. Using this assumption, Figure 8 gives as dotted lines the spectral distribution curves plotted to a fixed voltage scale. Reduced to a percentage-of-full-voltage scale the curves are drawn as full lines. Applying half value lead filters to the latter curves we obtain the curves drawn as full lines through the calculated points. In order to

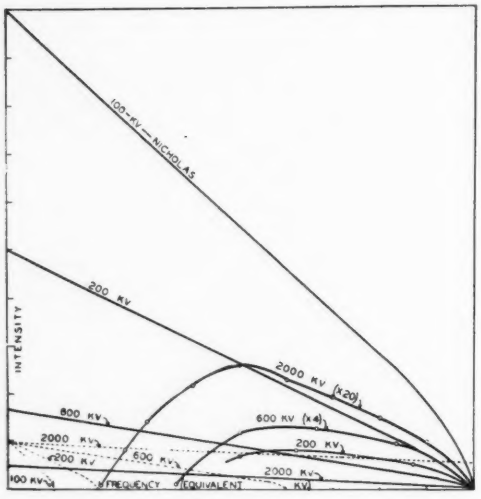

Fig. 9. Calculated spectral energy distributions for highly filtered x-rays, assuming x-ray efficiency constant. [As in Figure 7, dotted curves for actual frequency scale—area proportional to V; full-line curves for percentage frequency scale—area proportional to $1/V$; curves through points represent intensity distributions in heavily filtered beams at voltages as marked (multiplied by labeled factors for legibility).]

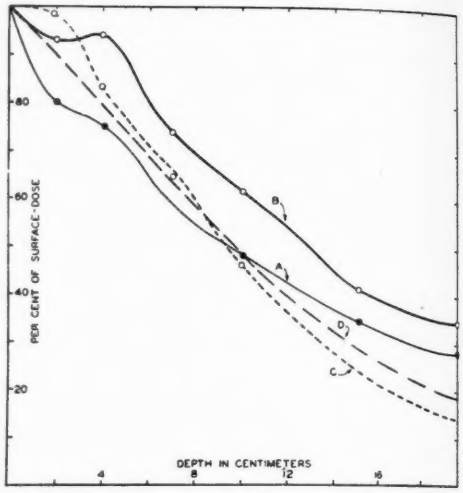

Fig. 10. Comparison of depth dose curves. [A and B calculated for 2,000 K.V., scatter correction from radium pack at 10-cm. and 20-cm. radium-skin distance; C and D 200 K.V. curves corrected to 100-cm. skin-target distance, from results of Weatherwax 200 K.V., 0.5 mm. copper, 2 mm. aluminium, and of Bachem 200 K.V., 1 mm. copper, 50-cm. skin-target distance, and 20-cm. portals.]

facilitate visual comparison with the filtered curve for 200 K.V., that for 600 K.V. has its ordinates multiplied by 2 and that for 2,000 K.V. by 3. It is again obvious that the average "hardness" of the filtered 2,000 K.V. radiation is under 1,000 kilovolts equivalent. As an extreme case we might assume the x-ray efficiency to be constant for all high voltages. Curves similarly calculated for this assumption are given in Figure 9. Again, we see that the average "hardness" of the filtered 2,000 K.V. radiation is under 1,000 kilovolts.

We may, therefore, assume for our depth dose calculations for a tube operated at 2,000 K.V. constant potential that the average "hardness" of the radiation passing a heavy filter will be approximately that of 1,000 K.V. monochromatic radiation. The depth dose curve for monochromatic 1,000 K.V. radiation is given in Figure 5 for a skin-target distance of 50 centimeters. We must correct this for the increase due to scattering, and, as above mentioned, the curve marked "Ra S D 10 cm." of Figure 4 is a generous allowance. Using these two curves, we obtain Curve A of Figure 10 as the depth dose curve to be expected when using a 2,000 K.V. tube with a heavy lead filter. To indicate the very maximum which might be possible we may use the scatter correction marked "Ra S D 20 cm." of Figure 4, although this is certainly an overestimation of the scatter correction by reason of the very large "portal" of the radium bomb. This correction gives us Curve B of Figure 10. The 10-cm. depth dose of a heavily filtered 2,000 K.V. tube may thus be expected to lie between 48 and 62 per cent, most probably about 50 per cent (of the skin dose). It is of interest to note that the 40 per cent depth dose of an ordinary 200 K.V. tube with moderate filters and a 20-cm. portal (Curves C and E of Fig. 2) may be raised to 48 per cent by changing the skin-target distance from 50 to 100 cm., by

reason of the inverse square law.[5] The 200 K.V. 20-cm. portal 100-cm. S.-T. D. curves are given as *C* and *D* of Figure 10. Figure 11 assembles for comparison a variety of the curves discussed.

In closing, the writer wishes to reiterate the fact that, since the dosage at the different depths is produced by x-rays of very different "hardness" in the two cases, the fact that the 10-cm. depth dose with a 2,000 K.V. tube may not be expected to differ greatly from that of a 200 K.V. tube must not be used for a basis of any conclusions as to their relative biologic effects. Only extended and unbiased experimental data can decide the relative value of very high voltage x-rays in therapeutic work.

The writer also records his appreciation that the Chemical Foundation of New York made possible the symposium on physical aspects of radiation which was presented at St. Louis, and of which this paper formed a part.

[5]Note added in press: Dr. C. C. Lauritsen has kindly pointed out to the writer that any increase in depth dose obtained by removing the (point) source of radiation to a greater distance is equally well obtained by the use of multiple portal irradiation. This is readily seen as follows: Neglecting absorption, and considering only the diminution due to the inverse square law, on a surface of area *A* at depth *d* cm., one may obtain a "depth-dose" equal to the skin dose (100 per cent) by using parallel radiation (strong source, far removed) and one portal of area *A*. One may equally well use a source at *d* cm. from the skin and four portals of area *A*/4, so arranged that each portal gives 100 per cent dosage to one-fourth of the skin area, while giving 25 per cent dosage to the area *A* at depth *d*. Any "absolute" gain in depth dose must come from a decrease in absorption ("harder" radiations) and not from a change in target-skin distance.

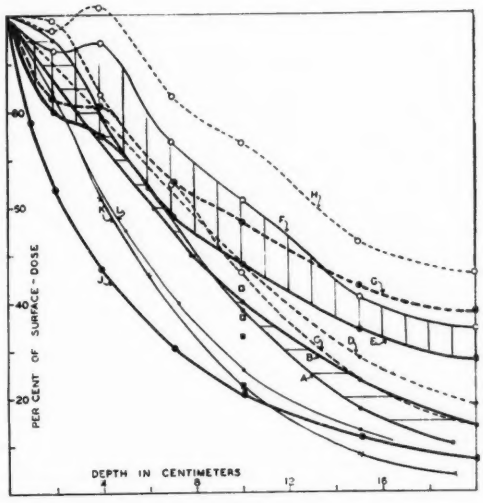

Fig. 11. Comparison of depth dose curves. [*A* and *B*—200 K.V., 50-cm. skin-target distance, Weatherwax and Bachem; *C* and *D*—curves *A* and *B* corrected to 100-cm. skin-target distance; *E* and *F*—calculated curves for heavily filtered 2,000 K.V. radiation, using scattering corrections from Figure 4, at 10-cm. and 20-cm. radium-skin distance; *G* and *H*—Curves *E* and *F* corrected to 100-cm. skin-target distance; *J*—radium pack depth dose, 10-cm. radium-skin distance (curve for 20-cm. radium-skin distance lies near *C*); *K* and *L*—200 K.V. curves, 5-cm. portals, Weatherwax and Bachem.]

ANNOUNCEMENT

The Executive Committee announces the Annual Meeting of the Radiological Society of North America will take place during the American Congress of Radiology, at the Palmer House, Chicago, Illinois, September 25 to 30, inclusive.

The business sessions will be as follows:

Sept. 25—Counselors Meeting—Luncheon. The names of the nominating committee will be read.

Sept. 26—Report of the Nominating Committee.

Sept. 28—Election of Officers.

These three meetings will follow the morning sessions of the Congress. Announcement as to room locations will be made in Chicago.

Sept. 29—Friday night—Convocation and Presentation of the Gold Medals by the Society at 8:30 P. M.

CASE REPORTS AND NEW DEVICES

A CASE OF HYPOGLYCEMIA TREATED BY RADIATION, WITH BENEFIT

By S. C. BARROW, M.D., SHREVEPORT, LA.

In reporting the following case, it is not our intention to even touch on the theories as to the causes of a low blood sugar content, found constantly or intermittently in certain individuals, accompanied by severe and alarming constitutional symptoms. We likewise feel uncertain as to the proper designation—spontaneous hypoglycemia or hyperinsulinism.[1]

Relative to the use of radiation in hypoglycemia or hyperinsulinism, we have been unable to find any mention or suggestion of its use in the literature on radiation. In the *American Journal of Roentgenology and Radium Therapy*, September, 1931, A. U. Desjardins gives a complete review of experiments showing the effects of radiation on the pancreas. None of these reports refer to hypoglycemic conditions, and the general conclusions are that pancreatic tissue and function are rather resistant and nonresponsive to radiation. In this review, however, of interest to us at this time, are the experiments of Tsuzuki (1926), which showed *distinct atrophy* of the *islands of Langerhans* in rabbits after full doses of short wave radiation.

CASE REPORT

On April 16, 1933, Dr. E. Powell, of West Monroe, La., referred the case here reported, with the request that we attempt relief by radiation.

The patient, D. W., was a white female, aged 9 years, weight 65 pounds, height 52 inches. The general physical appearance was healthy; mentally she appeared normal in every way soon after eating, but lapsed into dullness and inattention two or three hours after taking food.

She has one brother and two sisters, all normal and healthy. The father and mother claim to be in perfect health. The patient has an aunt, 22 years of age, who has been a confirmed epileptic since childhood (a hypoglycemic case, under treatment and improving; to be reported later); otherwise the family history is negative.

General physical examination discloses no defects; Wassermann negative; feces, blood counts, basal metabolism rate, all normal. When the patient was 5 years of age, her mother noted that the child seemed to be at times dull, listless, and stuporous, while, again, she was bright, cheerful, and playful. After some time it was noted that her stuporous spells occurred as her meal hours neared, and disappeared after she had eaten. As time passed, she began to have "spells" (so described by her mother), accompanied by unconsciousness. With experience, the mother gradually learned to guard against these attacks by feeding. At the age of 6 years, she entered school and found it uphill work. In the hours immediately after eating she could learn easily, but in her fasting hours she forgot it all, recovering her memory of previous lessons, however, as soon as food was taken.

During all this time, she received no medical attention and was known by the neighbors and school children as weak-minded. About January 1, 1933, Dr. Powell was consulted, who at once suspected the true condition. The patient's fasting sugar ran constantly around from 40 to 50 milligrams per 100 cubic centimeters; on feeding every two hours, it never went higher than 73 milligrams.

On April 16, 1933, she was given x-ray exposures over the anterior and posterior pancreatic areas, using 130 K.V.P., 4 ma., 3 mm. Al filter, 15-inch distance, 10 minutes to each area. During the period from April 23 to 30, her fasting sugar daily reached from 70 to 71 milligrams.

[1] To those interested in these phases of the subject, we would specially call attention to the following articles: Epilepsy and Narcolepsy Associated with Hyperinsulinism, Jour. Am. Med. Assn., Feb. 4, 1933, C, 321-328; Hyperinsulinism and Dysinsulinism, Endocrinology, Jan.-Feb., 1932, both by Seale Harris; an editorial in Southern Med. Assn. Jour., September, 1932, and an editorial in Ann. Int. Med., June, 1933.

On May 3, 1933, the same x-ray dose was repeated, and daily from May 7 to 15, during which time her fasting sugar daily ran from 72 to 80 milligrams.

On May 16, June 22, and July 23, one-half x-ray dose previously given was repeated, and her fasting sugar came up from 90 to 100 milligrams.

No change in diet was made after beginning the x-ray treatments. Coincident with the improved blood sugar content, her general condition improved, and her mentality rapidly changed over to normal for her age. She now takes zealous interest in all things that interest children, and has no "spells" or stuporous periods. Neighbors, teachers, and child companions comment on her changed condition.

We report this case of hypoglycemia as *temporarily* improved by radiation alone, making no claim at this time that radiation will *cure* hyperinsulinism. In this case it seemingly has temporarily, at least, controlled it. We have several other cases under treatment that are showing most gratifying improvement, to be reported later.

We can find no reference in the literature reviewed to other cases thus treated. We trust other radiotherapists will test the use of radiation in this condition and report their results. Normal pancreatic tissue has been proven not radiosensitive, but care should be exercised.

A SIMPLE MANEUVER TO INCREASE THE VISIBILITY OF A SALIVARY CALCULUS IN THE ROENTGENOGRAM[1]

By SAMUEL IGLAUER, M.D., CINCINNATI

It is often difficult to obtain a roentgenogram of a calculus in the submaxillary gland or duct because the shadow of the stone is obscured by the body of the mandible. However, if the roentgenologist places his finger in the patient's mouth and pushes down the floor, the submaxillary gland and duct can be depressed below the jaw bone and the calculus can then be brought clearly into view.

Figure 1 shows a calculus near the angle of the jaw in a roentgenogram taken in the ordinary way. In Figure 2 the same calculus can be seen to much better advantage below the mandible, and the shadow of the finger in the mouth is also visible. The small insert in Figure 2 is from an x-ray film of the same calculus after it had been removed.

Fig. 1 *(left)* and Fig. 2 *(right)*. See text.

[1]Presented at the meeting of the American Laryngological Association at Washington, D. C., May 8-10, 1933. X-ray films by Samuel Brown, M.D.

EDITORIAL

LEON J. MENVILLE, M.D. . . . . *Editor*
BUNDY ALLEN, M.D. . . . *Associate Editor*

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A WAY OUT

The present economic status of the people of the world is the result of disobedience of the "Golden Rule." Some may challenge this statement, nevertheless I am prepared to let it stand.

The remedy for the depressed conditions rests with us as individuals, families, communities, states or provinces, and nations. The individual must get his own house in order; the rest will follow naturally. You can, without stretching the imagination too greatly, visualize a group, a city, or a country made up of persons, each planning, conniving, even fighting for all he can corral for himself without thought of his neighbors. This self-centered existence has been in evidence too long. The ego must go. Our social service clubs are waving banners with high-sounding mottoes, but are the personnel of these clubs living in accordance with their preachings? It is not all economic either; one's mental attitude during the depression has made it difficult to distinguish or assess the value of those things necessary or worth-while, as compared with what was enjoyed in the days of prosperity or what propagandists have proclaimed as our rights. Wars, capital-labor differences, bitter contentions between political parties, religious organizations at variance, all have at the root of their strife selfish motives—coupled, it is true, with misunderstandings and mismanagement.

Let us face this mess with real courage, a determination that we are prepared to do our bit in the reconstruction and re-establishment of world affairs upon a more equitable basis; friendly co-operation, live and let live, and that we are starting right now.

"Whatsoever ye would that men should do unto you, do ye even so to them."

How can the members of the Radiological Society of North America apply such a Rule to their specialty?

1. *Our Patients.*—We should place ourselves in the position of the patients, conduct such examinations and treatments as seem desirable or necessary, in other words, work 100 per cent in the interest of the patients.

If we are not prepared to carry out the service as we know it should be done, we should not hesitate to call in assistance or refer our patients to another doctor or an institution where we know that they can secure the best.

2. *Our Referring Physicians.*—We must play the game; get acquainted with them so that we can communicate with them, expressing ourselves freely and knowing that our statements will not be misconstrued as being officious.

Give them honest reports after painstaking examinations and treatments. We may not be able to tell everything about a case—few are so gifted—but we should give all the information that we have secured since coming into contact with the patient. We must not be afraid to say we do not know, or that we consider it advisable to secure other medical opinion.

3. Our Competing Confrères.—Speak well of them or say nothing. Show them by example that we are practising our profession on a basis of fairness to all. In other words, we are putting into action our expressed ideals. Should our competitor be a culprit and do underhand, cut-throat things, that is no excuse for us retaliating in like manner—we would be placing ourselves upon his level and then he would feel justified in "beating us to it."

What do you think about getting as close to our competitors as possible? Familiarize ourselves with their philosophy of life, their good qualities and bad, physical and psychical, material and moral. Would it not be well to organize local groups for mutual advancement by study and free interchange of ideas? Nothing extinguishes the spark of a smouldering fire of impending strife like early frank discussions with all "the cards on the table," and nothing so sets the stage for such discussions as free social get-togethers, where we can grip the hand and use the moniker in greeting.

4. Our Distant Brothers in Radiology.—Some of us may be situated in large centers associated with clinics, richly endowed research institutions, or hospitals of enormous capacity, offering opportunities to a favored few. The volume of cases, the variety of conditions, and the privileged contacts enable some to secure an envious fund of knowledge. They should share this information. The higher your stratum in whatsoever field of endeavor, the greater is your responsibility to those less fortunate. Nothing we gain gives full value until we divide it with others. One should pass on the results of his observations and his achievements. Give to the radiologists less favorably situated your crystallized opinions proven by experiences, in order that the sphere of their usefulness may be enlarged by the application of successful methods. Too many good things have been lost to the world because of lack of whole-hearted distribution of the details of discoveries. Particularly is this fact applicable to the practice of medicine. We brought nothing into the world and we can take nothing away with us. Nothing that we leave to our own flesh and blood, if at the expense of suffering humanity, will ever be productive of good or happiness. Let each and every one of us disseminate our accumulated wealth of personally established worth-while methods. It is the doctors on the rapidly vanishing frontiers who will appreciate and put into practice these humanitarian aids. Stooping to capitalize upon accomplishments in medical science will redound throughout the ages and be recorded on the pages of history—against him who would withhold desirable information except for monetary consideration. Madame Curie and, before her, Professor Roentgen, exemplified the true scientists—they gave to the world the results of their toil and study without thought of compensation.

5. Our Society.—Many members of our Society and sister organizations, following up and enlarging upon the work of the founders of radiology, have sacrificed life and limb. We to-day are reaping the fruits of their labors. The names of these pioneers will ever be revered. It is incumbent upon us to emulate their triumphs by carrying forward the science so meritoriously inaugurated. They would ask of us nothing more than that we see to it that radio-activity gives the greatest good to the greatest number.

The foregoing thoughts are after meditation upon the state of so-called "defeatism" and my humble attempt to see "a way out." You may say that I am visionary, an idealist, that my theories are not workable. How do you know? Try them.

W. H. McGuffin, M.D.

COURSES IN ROENTGENOLOGY AND RADIATION THERAPY

The New York Post-graduate Medical School of Columbia University, New York City, has arranged to give new courses in roentgenology and radiation therapy this Fall. Any one interested may obtain full information by writing to the Registrar, Mr. Louis P. Aikle, 303 East 20th Street, New York City.

BOOK REVIEWS

PEPTIC ULCER: CLINICAL ROENTGENOLOGY, WITH CASE HISTORIES. By JACOB BUCKSTEIN, M.D., Instructor in Gastro-intestinal Roentgenology, Cornell University Medical College; Alimentary Tract Division, Roentgen Department, Bellevue Hospital; Consultant in Gastro-enterology, U. S. Veterans Bureau, Central Islip and Rockaway Beach Hospitals; Associate Attending Gastro-enterologist, Sydenham Hospital. Volume X, Annals of Roentgenology, edited by James T. Case, M.D., Professor of Radiology, Northwestern University Medical School. Second Edition, revised. A volume of 417 pages, with 334 roentgen-ray studies, 77 clinical illustrations, and 405 general illustrations. Published by Paul B. Hoeber, Inc., New York City, 1933. Price, $12.00.

Many specialists in roentgenology will be reluctant to pay the price for this book of slightly more than 400 widely margined pages and its text in twelve-point pica, dealing solely with peptic ulcer. Less than a fourth of the text is generally descriptive, and the remainder is devoted to case reports which are trite, largely repetitive, and not particularly illuminating. Lesions depicted are chiefly gross and most of them should be recognized at examination even by a novice. Yet the book is not devoid of merit as a primer and atlas on this theme.

The historical introduction is interesting, and many elementary facts concerning the morbid anatomy of peptic ulcer are presented attractively. On the whole, the book will have a certain appeal to undergraduate students and to clinicians, especially those who persist in attempting to make roentgenologic diagnoses by comparing roentgenograms with published illustrations. Perhaps the reviewer is hypercritical, but he feels that textbooks should take pains to correct the too-common notion that the roentgenologic diagnosis of gastro-intestinal disease is utterly simple and extremely facile, and should present the subject in sufficient detail to convey the fact that there is no royal road to this art.

A STANDARD CLASSIFIED NOMENCLATURE OF DISEASE. Compiled by the National Conference on Nomenclature of Disease. Edited by H. B. LOGIE, M.D., C.M., Executive Secretary. A volume of 702 pages. Published by the Commonwealth Fund, New York City, 1933. Price, $3.50.

This compact volume of slightly over 700 pages is the result of a series of conferences instituted by the New York Academy of Medicine in 1928 in an attempt to standardize, if possible, the nomenclature of disease. With the generous financial support of the Commonwealth Fund and the co-operation of representatives of some twenty-two scientific societies and five federal organizations, the Executive Secretary of the National Conference on Nomenclature of Disease has compiled the results of their deliberations in a comprehensive and convenient form.

The interrelations of roentgenology with almost every known branch of medicine and surgery in many institutions and in private practice sharpen the interest of the roentgenologist in an index that will make his material quickly and conveniently available.

With the aid of such a volume as this a non-professional could in time become familiar with the major codes of interest and accurately distribute, as a routine procedure, the various types of lesion, in which there may be something of roentgenologic interest. To those searching for the ideal in indices this small volume will come as a welcome aid. It seems but a question of time before facilities will be available to the majority of institutions

and even private practitioners to have their indices on punch card systems with their tremendous saving of time and effort. In the compiling of this volume this factor has been duly recognized. From all points of view this book should prove to be an interesting addition to the library of every roentgenologist.

ROENTGENOGRAPHIC STUDIES OF THE URINARY SYSTEM. WILLIAM E. LOWER, M.D., F.A.C.S., Chief of Department of Urology, Cleveland Clinic, Former Associate Professor of Genito-urinary Surgery, Western Reserve University, Surgeon to Cleveland Clinic Hospital, and BERNARD H. NICHOLS, M.D., F.A.C.R., Chief of Department of Roentgenology, Cleveland Clinic, Cleveland, Ohio. A volume of 812 pages and 812 illustrations. C. V. Mosby Company, St. Louis, 1933. Price, $16.00.

This volume, conveniently divided into 70 pages of reading matter and 732 pages of illustrations, with explanatory text, affords a most comprehensive review of the subject and will have a distinct place as a manual of instruction and also as a reference book in deciding the problems presented in the daily routine.

In the text one is given the benefit of the wide experience of these co-workers in the field of urology and roentgenology. Many practical points in the preparation of the patient and on radiographic technic have been incorporated. The chapter on roentgenographic examination of the male urethra thoroughly covers the points of a procedure that seems to have been difficult to many. "Intravenous urography," or, as they have suggested in their text, "excretion urography," a term gaining in popularity to describe this procedure, is brought up-to-date in a compact and comprehensive manner which will clarify for many the voluminous literature of the past decade on this subject. The inclusion of a chapter on conditions which affect the upper right abdominal quadrant that often closely simulate and are mistaken for urologic pathologic processes, adds distinctly to the value of this volume. The inset of a schematic drawing in the reproduction of the individual roentgenogram aids materially in the interpretation of the illustrations as presented, and the addition of the history in each case makes it at the same time an instructive text-book and a valuable reference volume. Particularly interesting are the wide range of normal pyelograms, with the variations due to incomplete filling and other reasons, and the renal anomalies. These will, no doubt, be of distinct value to those of lesser opportunity and experience in their doubtful cases.

The book reflects a wealth of material, well segregated and carefully studied, and is a distinct addition to the literature on this subject.

LES COURANTS DE HAUTE FRÉQUENCE EN GYNÉCOLOGIE (High Frequency Currents in Gynecology). A. LAQUERRIÈRE, Electroradiologiste des hôpitaux de Paris, Directeur des services d'électro-radiologie et de physiothérapie de l'Hôpital Notre-Dame (Montréal), and D. LÉONARD, Assistant des services d'électro-radiologie et de physiothérapie de l'Hôpital Notre-Dame (Montréal). Preface by Pr. D'Arsonval. A volume of 138 pages with 25 illustrations (Collection Médecine et Chirurgie pratiques, No. 52). Published by Masson et Cie., Paris, 1932. Price, 18 francs.

This is a small manual explaining in simple terms the uses of high frequency electrical currents in gynecology. The beginning of the book is devoted to an explanation of apparatus and methods, and the latter part to diseases and the high frequency treatment best fitted to deal with them. The subject is well handled and on the whole the opinions expressed are sound and the relative merits of different methods are adequately set forth. As a simple presentation of the question of high frequency treatment in gynecology it may here and there give an impression that this method of treatment is more valuable and that its scope is greater than is actually the case, but this is merely due to brevity.

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APPARATUS

Shortcomings of Tank Development: Ways for Improvement in the Technic of Development. Hans Lewin. Röntgenpraxis, May, 1932, IV, 445-451.

Tank development, although generally used, is not as ideal as one is led to believe. The quality of a roentgenogram developed in a tank is far inferior to one developed by moving in a tray. How much the quality of a roentgenogram is influenced by the development is unknown to the roentgenologist; however, the importance of time and temperature is known. The mechanical conditions during development have not been studied sufficiently.

Aluminum and lead figures were roentgenographed. The films were developed in a tank and below each shadow of a figure a band-like shadow could be seen, which gradually disappeared in the normal black surroundings. If the film is developed by moving it in a tray, this phenomenon is not present. The explanation is probably a sinking of free bromin, combined with the alkali of the developer. As a developing solution which contains a lot of bromin is slow, the area just below is only partially developed. The medical roentgenogram might show this in films containing lead numbers; but naturally all other shadows of increased density must show the same thing, even if not noticeably. Tank development leads to a loss of contrast. If one puts the exposed film in a tray of water at 20° C. and moves it for ten minutes, the development is influenced. It increases the intensity of the developing process so much that only one-half of the normal exposure time is necessary. Apparently well controlled exposure and determination of film blackening by a photometer showed that films developed by moving in a tray had a 100 per cent blackening; films developed and not moved in a tank had only 65.5 per cent. If the film was moved in the tank six times during six minutes, the factor was 96.5 per cent.

If the exposed film is moved about in plain water, as previously described, and is then moved about in a tank or tray, the exposure time can be shortened to one-fourth of the time, as compared with the technic of not moving the film in the tank. The author shows roentgenograms to prove this contention. He suggests the installation of a pump arrangement in the tank to keep the developing solution in constant motion.

H. W. Hefke, M.D.

BONE DISEASES (DIAGNOSIS)

Lead Poisoning in Children. H. S. Mitchell. Can. Med. Assn. Jour., May, 1932, XXVI, 546-549.

The author presents two case reports of lead poisoning in children, calling attention particularly, from the x-ray standpoint, to the dense lines seen in the epiphyses of the long bones. This condition has been noted in the last few years by Park, Jackson, Kajdi, and Vogt.

Specimens from autopsy material showed that there was four times the amount of lead in these areas than farther back in the shaft of the bone. Park also demonstrated that microscopically the trabeculæ are much more dense in these radiologically dense areas.

While these dense areas are found in other conditions, such as healing rickets, scurvy, and congenital syphilis, yet the associated symptoms are sufficiently characteristic for differential purposes.

Other metals may produce similar densities.

L. J. Carter, M.D.

Pseudo-fractures in Arthritis Deformans of the Hip. A. Herzog. Röntgenpraxis, March, 1933, V, 174-177.

Roentgenograms of arthritic hips show occasionally a bandlike zone of decreased density running horizontally through the head, which might present the appearance of a fracture. Three such cases are described. The author believes that this phenomenon is due to an extensive calcification and ossification of the joint capsule, which does not attack a narrow, limited zone. It looks on the roentgenogram like a fracture. Movement of the joint and capsule seems to prohibit deposition of calcium in this limited area.

H. W. Hefke, M.D.

Fragilitas Ossium and Blue Sclerotics. H. S. Sharpe. Can. Med. Assn. Jour., August, 1932, XXVII, 174.

This is a case report of a painless fracture of the right humerus, produced by a slight twist of the arm. This was the fifth fracture the patient, a young female, had sustained, all being due to slight trauma. Three of the fractures had occurred before the age of fourteen years. On inquiry into the early history it was found that the patient did not walk until the age of five. She wore steel braces to support the legs from that time until she was nine. At the age of fourteen she was treated for scoliosis and wore a cast for six months.

Her eyes exhibited the typical blue sclerotics of fragilitas ossium. Her father also had the same pigmentary defect and had sustained many fractures. One brother also had blue sclerotics and had had many fractures.

A radiograph of the head showed some tendency to thickened islands of bone in the vault and wide suture lines. The long bones showed the cortex to be thin and dense and the medullary cavity comparatively large.

L. J. Carter, M.D.

CHEST (DIAGNOSIS)

Pneumoconiosis of Porcelain Workers. Leopold Holst. Röntgenpraxis, May, 1932, IV, 409-422.

Serial examination of cases with pneumoconiosis (Stages I and II) shows that they do not change their character appreciably in the course of years. One may see changes progressing from Stage I to Stage II, but not to Stage III. In the larger number of cases, which presented a roentgen appearance of Stage III, cavitations were seen to develop in time and tubercle bacilli were demonstrable in the sputum. There is no reason to believe that in Stages I and II there is a combination of pneumoconiosis and tuberculosis. Stages I and II, according to the commonly used classification, must be considered pure pneumoconiosis, while the picture of the third stage is based not only on a pure silicosis, but on a tuberculopneumoconiosis.

Patients with silicosis are very liable to acquire a tuberculosis of the lungs. Tuberculosis, which complicates a fully developed silicosis, runs a slow course (fibrous type), but usually ends with the formation of cavities, leading quickly to death. The pneumoconiosis is *per se* a rather harmless disease, but predisposes to grave complications. The prophylaxis must be strict; technical improvements in removal of the dust, removal of the danger of tuberculous infection from the surroundings of a patient with silicosis, dismissal of all patients with open tuberculosis from the shops, and transfer of all workers with pneumoconiosis of Stage II into dust-free occupations.

H. W. Hefke, M.D.

Roentgenograms of the Disappearance of a Large Tuberculous Cavity in a Lower Lobe. F. Seeber. Röntgenpraxis, May, 1932, IV, 434, 435.

The disappearance of a large cavity in a lower lobe in a few months is not often seen. The author cites a case in which the cavity was the size of an apple and surrounded by tuberculous foci. The sputum of the patient was positive for Koch's bacilli. After a few months the cavity disappeared and the lung was almost entirely free from pathologic changes. Even after two years the patient remained symptom-free.

H. W. Hefke, M.D.

CONTRAST MEDIA

The Use of Thorium Dioxide in the Diagnosis of Liver Abscess. Robert J. Reeves and Elbert D. Apple. Jour. Am. Med. Assn., May 27, 1933, C, 1682, 1683.

The authors report the use of thorium dioxide in 12 c.c. doses with a total dosage of 72 c.c. over a period of 14 days to define the liver abscess. Roentgen examination of the abdomen three days after the last injection disclosed a markedly enlarged liver and a large rounded area of diminished density situated in the posterior portion of the liver, measuring 14 cm. in diameter. The abscess was aspirated and about 300 c.c. of pus was obtained.

The authors have reviewed the literature and discussed the distribution of the thorium in the tissues and the inherent dangers in the use of thorium dioxide.

C. G. Sutherland, M.D.

Roentgen Visualization of Liver and Spleen with Thorium Dioxide Sol, with Particular Reference to the Pre-operative Diagnosis of Carcinomatous Metastases to the Liver. Lester G. Ericksen and Leo G. Rigler. Jour. Am. Med. Assn., June 3, 1933, C, 1758-1764.

Radt, in 1929, was able to visualize the liver and spleen and demonstrate gross changes very beautifully with a fine colloidal suspension of thorium dioxide. The colloidal particles of radiopaque thorium dioxide are phagocytosed by the recticulo-endothelial cells of the liver and spleen, thus casting a shadow of these organs on the x-ray film. The authors report the results of this procedure as a routine examination pre-operatively in cases of malignancy, particularly those of the gastro-intestinal tract. In a series of 82 cases of various types they found the clinical application to be surprisingly broad and useful. Elimination is slow and probably occurs through the intestine and the lungs.

The authors have recently undertaken the study of the effect of various drugs in hastening elimination. While most investigators have yet to discover any damaging effects when used in the doses necessary for diagnostic valuation, it has not been definitely proved that the procedure is entirely harmless. A total dose of 0.8 c.c. of thorium dioxide sol per kilogram of body weight gives a diagnostic shadow of liver and spleen when detail is wanted. This is given in three equal doses on successive days. Several times the authors have visualized detail well with 50 cubic centimeters. It is always advisable to give the smallest possible dose. The speed of injection makes little difference, but it is important to warm the preparation to body temperature before giving it. The films should be taken not sooner than 24 hours following the last injection and they are better at 48 hours. Interpretation of the films depends on the constancy of the rarified areas as to location and size in a series of films. When in doubt it is preferable to make an error on the negative side.

Charles G. Sutherland, M.D.

Thorotrast: A New Contrast Medium for Radiological Diagnosis. W. H. Dickson. Can. Med. Assn. Jour., August, 1932, XXVII, 125-129.

In the latter part of 1930 Paul Radt discussed his method of the administration of thorium in a colloid

solution of high dispersion and low—or no—toxicity, for the study of diseases of the liver and spleen by the radiological method. From then, considerable research has been continuing abroad with the new medium. In September, 1931, Dr. Dickson and his confrères were requested to carry out experimental work in the University of Toronto and Toronto General Hospital.

The radiological work done was supplemented by research work on animals by the Department of Medical Research, Banting Institute, and by the Department of Surgery, both of the University of Toronto. The animal research work was done by Dr. D. A. Irwin, and the surgical work by Dr. I. G. Macdonald. The clinical and animal research findings of these two men are reported in separate papers in the same issue in which Dr. Dickson's paper is published.

Thorotrast is deposited chiefly in the liver, spleen, bone marrow, and lymphatic glands, while smaller amounts are found in the adrenals and ovaries. None has been found in the testicles. Normal lungs and kidneys show no deposit, while in disease of the lungs or kidneys the thorium is found deposited in these organs. No evidence of elimination of thorium from the spleen, bone marrow, lymphatic glands, or ovary has been observed in a period of four months, but there is a small amount from the adrenals. The chief organ of elimination is the liver, about 50 per cent remaining in the liver in three months. This elimination goes on through the central vein of the liver, through the right heart into the lungs, where the thorium-laden Kupffer cells stick in the capillaries and are eventually thrown off in the mucus from the bronchial tubes. During the stage of elimination the thorium is recoverable from the lungs. No reaction was noted in any case.

The technic was as follows: A daily dose of thorotrast was given intravenously, 25 c.c. a day for three days. On the fourth day films were made. This was repeated daily until the greatest concentration was noted in the spleen and liver.

A well-outlined liver, smooth and homogeneous in density, rules out carcinomatous changes. Metastases are seen as areas lacking in density and having a punched-out appearance. Similar appearances are found in the spleen. Cysts in either organ are seen as clear areas. Changes in size of either organ are noted. This method will be found of great value in the differentiation of abdominal tumors in the left and right hypochondrium.

The method is of value in diagnosing brain lesions, such as tumors, atheromatous changes of encephalic arteries, and meningitis. Thorotrast (8 to 15 c.c.) is injected into the common carotid through a platinum needle, 1 mm. in diameter, bent or bayonet-pointed. The same solution may be used in retrograde urography, as well as in fistulous tracts in empyema and bronchiectasis.

L. J. Carter, M.D.

DOSAGE

The Problem of Dosage in Temporary Sterilization by Irradiation. Th. C. Neeff. Strahlentherapie, 1932, XLV, 734-739.

The problem of dosage in temporary sterilization is discussed from the physical standpoint. The author shows, for instance, that changes in position may lead to considerable inaccuracies if measurements are carried out during irradiation by placing the chamber in the vagina. With proper technic the total error of determining the dose effective in the ovaries will not exceed ± 5 per cent. From the standpoint of dosimetry, therefore, no objections can be raised to temporary sterilization.

Ernst A. Pohle, M.D., Ph.D.

Preliminary Experience with the Protracted Fractional Dose Method. G. Herrnheiser. Strahlentherapie, 1933, XLVI, 435.

This is a brief report of the author's experience with 48 patients treated according to the Coutard method. He usually gives 7.5 r per minute filtered through 2 mm. Zn or 1.2 mm. Cu, the daily dose being from 300 to 400 r, the total dose 4,200 to 4,800 r per field. The method was tried only in advanced cases: in 22, the tumor definitely decreased in size; in 14, there was a partial response, and in 12 no effect could be seen. Although his experience is not large the author considers the method as promising in suitable cases.

Ernst A. Pohle, M.D., Ph.D.

EXPERIMENTAL STUDIES

Roentgenologic Demonstrations of the Human Brain in a Living Subject. Berlin letter in Jour. Am. Med. Assn., May 27, 1933, C, 1707.

In the *Klinische Wochenschrift*, A. Radovici and O. Meller report on a new method for the roentgenologic demonstration of the human brain in the living subject. They experimented with methods of demonstrating in roentgenograms the plastic relief of the central nervous system by obscuration of the spinal fluid with the aid of a contrast medium. For this purpose they injected a colloidal solution of thorium dioxide into the spinal canal or into the brain, first into the dead bodies of new-born infants and later into dogs, rabbits, and apes. The sulci between the convolutions of the brain appear as black narrow stripes, whereas the convolutions stand out in relief. The spinal cord itself appears to be limited by two black parallel bands, which correspond to the shadow-producing spinal fluid. Since, after from one to two months, the relief outlines of the central nervous system have become much paler and the dark stripes appear only as fine lines, it may be assumed that the injected substance is gradually absorbed and disappears from the surface of the

brain. The animals treated in this manner do not behave differently from the controls. The authors believe, therefore, that the favorable results justify the use of this or similar technic on man. The use of thorium salts for a demonstration of other organs has been known for several years.

C. G. SUTHERLAND, M.D.

FOREIGN BODIES

Foreign Body in Mediastinum; Esophagoscopic Removal under Roentgenoscopic Guidance. Herman J. Moersch and B. R. Kirklin. Jour. Am. Med. Assn., Jan. 21, 1933, C, 169, 170.

In this case a new endoscopic experience in the treatment and removal of a foreign body, lying entirely in the mediastinum, is reported. A girl, aged 3 years, began to suffer from dysphagia two months previous to admission. The dysphagia gradually progressed, failing to respond to various types of medical treatment. Roentgen examination revealed a foreign body at the level of the arch of the aorta and presumably in the esophagus. A week previous to admission mediastinitis and pneumonia developed. Roentgenoscopic examination showed the foreign body to be outside the lumen of the esophagus and this was confirmed by esophagoscopic examination. The child was permitted to return home and was brought back 25 days later. She was in poor condition and much dehydrated. Roentgenographic examination showed that the inflammatory reaction had subsided. After surgical consultation it was decided to attempt removal by the esophagoscopic approach. Under roentgenoscopic control the foreign body (a small lead horse, with a rider) was broken into pieces and removed. The rider dropped into the esophagus and was allowed to pass naturally. Immediately following the esophagoscopy, a temperature of 104° F. developed. The temperature returned to normal on the next day and the child was able to take liquids without difficulty. The patient gained five pounds in weight in the first week and has had no further difficulty.

C. G. SUTHERLAND, M.D.

Open Safety Pin in the Stomach of a Two-months-old Baby. Harry Otten. Jour. Am. Med. Assn., March 11, 1933, C, 736.

A baby girl, aged 2 months, swallowed an open safety pin. The roentgenogram and roentgenoscopic examination for each of six successive days showed the safety pin in the cardiac end of the stomach in the same position as when swallowed. Bread, potato, and cooked cereals were given in addition to regular nursing. After six days surgical intervention was decided upon. An abdominal incision was made, the pin was closed by manipulation through the stomach wall, a stomach tube was passed, and the closed safety pin was manipulated into the stomach tube and withdrawn without difficulty.

C. G. SUTHERLAND, M.D.

Foreign Body in the Duodenum: Report of Case and Method of Removal. Sidney W. Raymond. Jour. Am. Med. Assn., Feb. 4, 1933, C, 337.

A case report of an infant, aged 14 months, who swallowed a "bobby pin." A roentgenogram showed the pin lying in the fundus of the stomach. The child was placed on a diet consisting mainly of vegetables and citrus fruit pulp. Subsequent roentgenographic studies showed the pin lodged in the second portion of the duodenum, where it remained for 52 days before consent was received for surgical intervention. Previous to operating, a pin of the same kind and size was found to slide with moderate ease into the side opening of a No. 20(F) catheter. Under ether anesthesia, an upper right rectus incision was made. The pin was milked into the stomach and through the thin wall of the stomach was easily placed point-first inside the catheter (presumably passed by mouth, though not stated), the same as in the practice test, and brought out through the mouth. Recovery was uneventful.

C. G. SUTHERLAND, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Internal Fistulas of the Biliary Tract. R. Prévôt. Röntgenpraxis, March, 1933, V, 177-182.

About forty cases of roentgenologically diagnosed internal fistula of the biliary tract have been reported in the literature. Such fistulas are possible between the biliary tract and the gastro-intestinal canal, between parts of the biliary tract itself, the biliary tract and the vena porta, the urogenital system, and finally, the thorax, by communication of a liver abscess with a bronchus of the right lung. The cause for spontaneous fistulas is usually chronic inflammatory disease of the biliary tract, with or without stones; less often, perforating ulcers of the stomach and duodenum. Most of the cases reported in the roentgenologic literature are gall bladder-duodenum fistulas. Only four fistulas between gall bladder and colon have been reported. The clinical symptoms might be typical—that is, symptoms of an acute perforation, with temperature, chills, etc.—or might be very slight. The roentgenologic diagnosis is usually not difficult; air in the gall bladder on the flat film, barium in the biliary tract after a colon enema or barium meal, are pathognomonic. Usually the mucosa of the stomach or duodenum or colon is markedly hypertrophic and distorted in the region of the fistula. Occasionally one may demonstrate gallstones in the lumen of the bowel, which are responsible for intestinal obstruction.

H. W. HEFKE, M.D.

Radiologic Exploration of the Appendix. Silvije Kadrnka and R. Sarasin. Jour. Am. Med. Assn., Oct. 1, 1932, XCIX, 1183, 1184.

The authors have an article in *Presse medicale*, illustrated with roentgenograms. Some workers have administered, with the contrast medium, stimulants of intestinal contraction. Kadrnka and Sarasin first give the patient castor oil and then apply a lavage of the large intestine with water. The barium enema is given with the patient in the Trendelenburg position, the distention of the cecum being controlled under the fluoroscope. After evacuation of the opaque enema, air is injected under fluoroscopic control. The image of the cecum is represented by the outline of the thin layer of barium which remains adherent to the cecal mucosa. The appendix is frankly visible. Non-visibility of the appendix justifies suspicion of the existence of important lesions. Of 24 cases presenting an invisible appendix, 16 were operated on and all showed lesions.

C. G. SUTHERLAND, M.D.

Ectopy of the Cecum: Clinical and Radiologic Gastro-duodenal Syndrome of Subhepatic Appendicitis. M. Santoro. Archivio di radiologia, 1932, VIII, 355-371.

The author describes two cases of anomalous position of the cecum and appendix, inflammation producing the clinical and radiologic symptoms of ulcerating lesions in the stomach and duodenum. The symptoms in the stomach and duodenum were probably due in part to adhesions and partly to reflex phenomena. The author shows the importance of x-ray examination of gastro-intestinal lesions, especially to bring out anomalous positions of the viscera, and emphasizes the necessity of appreciating morphologic changes in the various organs which are always brought out by a careful and thorough examination.

E. T. LEDDY, M.D.

Roentgen Studies of Patients with Gastro-intestinal Food Allergy. Albert H. Rowe. Jour. Am. Med. Assn., Feb. 11, 1933, C, 394-400.

Four patients with marked and prolonged gastric symptoms which had been relieved by the elimination of specific foods, were selected. Careful physical examinations and laboratory studies had ruled out other causes. The re-introduction of the same foods in the diets had reproduced the symptoms on more than one occasion in each patient. Roentgen observations consisted of fluoroscopic examinations and roentgenograms made immediately on the ingestion of barium and 3, 10, and 24 hours thereafter. Such studies were first made when the patients had been free from their symptoms for several weeks.

About two or three weeks after this initial study a second series of observations was made after the patients had taken milk or milk and egg for one or two days. The barium was also administered in malted milk, to which each patient was sensitive. Marked disturbances in muscular tone and motility resulting from probable allergic reactions in the gastro-intestinal tissues were observed in each of the patients.

C. G. SUTHERLAND, M.D.

Cystic Myoma of the Ileum, with Intestinal Hemorrhage. George G. Finney. Jour. Am. Med. Assn., Feb. 11, 1933, C, 408-410.

This is a case report of a patient with no other history of import than persistent blood in the stools. Fluoroscopic examination showed a large, prolapsed stomach, very active, and contracting vigorously. The pyloric end was deformed as the result of operative intervention. No actual deformity was seen. Films showed a "cow-horn type" of stomach, hypertonic, with good motility, and spastic. A defect in the duodenal cap suggested ulcer. There was slight retention at the end of 24 hours. Proctoscopic examination did not show anything abnormal. Abdominal exploration revealed a mass the size of an orange in the region of the sigmoid flexure. At a later date a second operation was performed and this mass was resected. Microscopically it was shown to be a cyst wall made up of flattened, rather broad strands of a dense connective tissue. The final diagnosis was myoma of the ileum, with cystic degeneration and hemorrhage.

C. G. SUTHERLAND, M.D.

Duodenocolic Fistula, with Incompetent Sphincter of Oddi. Clarence E. Rees. Jour. Am. Med. Assn., Feb. 18, 1933, C, 496.

This is a case report of a fistula between the duodenum and the colon, not secondary to a malignant growth. Traction from the fistulous tract had resulted in incompetence of the sphincter of Oddi, so that the contents of the duodenum was allowed to pass into the bile passages. The liver had suffered no apparent damage in spite of the fact that it had been subjected to regurgitation of the contents of the duodenum and the colon over a long period. Roentgen examination of the gastro-intestinal tract showed partial filling of the common bile duct with barium and distribution of the barium throughout the ramifications of a portion of the hepatic ducts. Post-operative roentgen examination demonstrated that duodenal contents was still regurgitating into the bile ducts, apparently because of incompetence of the sphincter of Oddi.

C. G. SUTHERLAND, M.D.

HEART AND VASCULAR SYSTEM

Coarctation of the Aorta, with Report of Three Cases. G. F. Strong. Can. Med. Assn. Jour., July, 1932, XXVII, 15-19.

The occurrence in the author's practice of three cases of this rare disease within the period of a little over a year makes this series of case reports interesting.

The first case was that of a gardener, aged 18, who had been ill for two weeks, the diagnosis being rheumatic aortic valvular endocarditis. He made an apparently good recovery and resumed his usual occupation. Sixteen months later he suddenly collapsed while skating and was dead before arriving at the hospital to which he was being taken. At autopsy the pericardial sac was found to be distended with blood from a tear in the dilated and thinned ascending aorta, proximal to a narrow constriction.

The second case was that of a carpenter, aged 38, following an attack of cardiac decompensation after an illness of two years. At autopsy there was found an extreme constriction of the aorta 2 cm. distal to the origin of the left subclavian artery. X-ray films of the chest showed enlargement of the heart, density at the right base, and irregular erosions along the lower margin of the upper ribs.

The third case was that of a school girl, aged 12, who died of renal failure following an attack of scarlet fever. At autopsy there was found a chronic nephritis, and the aorta showed a coarctation in the descending portion of the arch.

The author makes the comment that, while the diagnosis of coarctation was not made in any of these three cases during life, yet the possibility of this condition should be borne in mind when dealing with cardiac and aortic conditions.

L. J. Carter, M.D.

Status and Clinical Application of Roentgenology of the Thoracic Aorta. John Sproull. Am. Jour. Roentgenol. and Rad. Ther., July, 1932, XXVIII, 37.

X-ray examination is an essential in the diagnosis of aortic disease, for with such study, aortic pathology, not discoverable by other methods of examination, may be demonstrated, and the study is also valuable in helping to exclude aortic disease as the cause of intrathoracic symptoms. Clinical diagnosis by methods not including x-rays is attended by a considerable diagnostic error, especially in syphilitic aortitis. Reid found an error of 44 per cent in 78 autopsy cases. There are many conditions, including angina pectoris, paroxysmal dyspnea, unexplained cough, unusual pulsations, aortic valve disease, and others which should have the benefit of roentgen examination of the great vessel. Among the reasons why cardiovascular x-ray studies are not more frequently made are: (1) many roentgenologists are not familiar with the technic of the examination nor of the normal and pathologic anatomy and are, therefore, unable to give the clinician the essential degree of co-operation; (2) many practitioners feel able to diagnose aortic disease without x-ray assistance, (3) the value of x-ray study is not well known to the profession in general or to the laity. It is important to remember that the Wassermann may be negative in from 15 to 40 per cent of cases of syphilitic aortitis. Both the arteriosclerotic and syphilitic forms of aortitis are fairly common diseases, hence the frequent need of roentgen methods to supplement the clinical findings and the Wassermann test.

J. E. Habbe, M.D.

A New Sign of Pericardial Effusion. Eli Moschcowitz. Jour. Am. Med. Assn., May 27, 1933, C, 1663, 1664.

There are three signs usually conclusive in determining the diagnosis of pericardial effusion: (1) widening of the area of cardiac flatness; (2) abrupt transition from pulmonary resonance to cardiac flatness, and (3) widening of the cardiac dullness in the second intercostal space. No one of these signs, taken singly, is conclusive, but together they form a triad which is thoroughly reliable, as confirmed by roentgen examination or at autopsy. The widening of the cardiac outline in the second intercostal space is merely another evidence that pericardial effusions have a pronounced tendency to accumulate at the base of the pericardial sac. This widening is confirmatory of one of the important diagnostic criteria of pericardial effusions in roentgen diagnosis, namely, the increased widening of the cardiac shadow at the apex of the cardiac triangle.

C. G. Sutherland, M.D.

Roentgenographic Studies of the Right Ventricle. G. Nemet and J. B. Schwedel. Am. Heart Jour., June, 1932, VII, 560-573.

By means of barium placed in the interventricular grooves of isolated human hearts, the exact location of this groove was determined for the various radiographic projections. Particularly in the left anterior oblique position, the site of the interventricular groove was verified as being consistent with a groove on the left lower contour frequently seen in fluoroscopy.

Studies made of the inflow and outflow tracts of the right ventricle are also described. The first demonstrable changes occurring in right ventricular enlargement being those of the outflow tract, they are represented roentgenologically by a prominence in the region of the pulmonic conus in the postero-anterior projection. A displacement of the interventricular groove to the left and upward and a prominence of the ventral border of the heart below the angulation are observed in the left anterior oblique when the inflow tract of the right ventricle is enlarged.

Nathan Flax, M.D.

THE JOINTS

Chondromalacia of the Patella: Fissual Cartilage Degeneration; Traumatic Chondropathy: Report of 3 Cases. Jacob Kulowski. Jour. Am. Med. Assn., June 10, 1933, C, 1837-1440.

Chondromalacia of the patella is characterized by a circumscribed primary degenerative fibrillation, fissuring, and erosion of its articular surface. It occurs as a solitary lesion or may be associated with other common causes of internal derangement of the knee joint. In either event, it has been shown to be a definite clinical entity. Pathologically, it is a localized form of arthritis deformans (so-called hypertrophic type). First clinically recognized by Budinger in 1906 and again in 1908, who called it "fissures of the patellar cartilage." The more appropriate term "chondromalacia" originated with König in 1926.

Chondromalacia of the patella usually occurs in the young. The history is one of chronic disability, with general symptoms of internal derangement of the knee joint. Pain, as a rule, is referable to the patella or to its immediate vicinity. The intermittent hydrops attending exertion is due to the inevitable secondary synovial sequelæ. Characteristically there is localized patellar pressure-tenderness in acute flexion. The roentgenogram reveals little of definite value even when the ulceration is markedly advanced, but is strongly suggestive when slight hypertrophic changes are noted about the joint, in addition to these signs and symptoms. Roentgen examination is, however, absolutely essential for a differential diagnosis. An exact diagnosis can be made only when the patella is adequately exposed surgically.

Trauma must be assigned as the primary activating force on a background of constitutional predisposition, the poor regenerative power of the cartilage, and the peculiar mechanism of the knee joint.

CHARLES G. SUTHERLAND, M.D.

Regeneration of the Distal Phalanx. L. H. McKim. Can. Med. Assn. Jour., May, 1932, XXVI, 549, 550.

It has been known for many years that the distal phalanx is able to regenerate following the removal of the diaphysis for osteomyelitis which has not involved the proximal or epiphyseal portion of the bone, or the interphalangeal joint. The number of cases in which amputation is performed following osteomyelitis of this bone leads one to suspect that this ability to regenerate has either been forgotten by many of us, or that it has not been sufficiently emphasized.

The author presents a case report from the Montreal General Hospital. Following an osteomyelitis of the distal phalanx of the right middle finger an x-ray film showed that sequestration of the shaft had occurred but that the interphalangeal joint was intact. At operation the diaphysis was removed but the epiphysis was untouched. Subsequently the bone regenerated, as shown by a series of x-ray films.

L. J. CARTER, M.D.

Contribution to the Hereditary Factors in Multiple Cartilaginous Exostoses. Heinz Kirchhoff. Röntgenpraxis, June, 1932, IV, 383-387.

It is generally known that multiple cartilaginous exostoses are frequently found in different members of the same family. A family tree is reproduced, the examination of which shows that there is only direct transmission. Healthy members do not transmit a predisposition to cartilaginous exostoses or enchondromas. It seems necessary to collect more such family trees, as only a comparatively small number of them has been published.

H. W. HEFKE, M.D.

Examination of the Elbows of Tennis Players. W. Knoll. Schweiz. med. Wchnschr., July, 1932, LXII, 640-643.

The author conducted radiographic examinations of the elbows of various participants in the International Tennis Tournament in Germany. Although all but one of the patients examined had been actively engaged in tennis playing for more than five years, the demonstrable changes were negligible. The few pathologic changes that were demonstrated had an adequate traumatic background. Thirteen of the players had played in various matches for over ten years, and no bone changes were demonstrated in any of them. The author concludes that the so-called "tennis elbow" is a rare manifestation.

H. C. OCHSNER, M.D.

THE MASTOID

The Early Recognition of Otitic Intracranial Complications. V. V. Wood. Laryngoscope, May, 1932, XLII, 335-355.

This extensive and important subject is considered under the following heads: (1) Physical examination; (2) Temperature curve; (3) Bacteriologic study of the secretions from the middle ear and mastoid; (4) Lumbar puncture; (5) Blood picture; (6) X-ray examinations.

While Dr. Wood does not add any new points to x-ray interpretation, he ably reviews the subject. He stresses the importance not only of x-ray examination of the mastoids, but also of using the x-ray as a means of differential diagnosis from other conditions with similar temperature curve and blood

picture. He specifically mentions pulmonary conditions in this connection.

The rather detailed discussion of mastoid interpretation brings out or emphasizes the following: (1) It is not always possible to differentiate old and new pathology, and passive processes may be misinterpreted as active ones. (2) Films may not show mastoiditis until several days after definite clinical manifestations. (3) Occasionally the x-ray findings are exaggerated. (4) Serial films are frequently helpful in making a diagnosis. (5) As healing occurs there is an increasing thickening of the "mucosa and intracellular contents." This fibrosis and sclerosis cause an increased opacity on the films that must be differentiated from a progress of the original infection.

On the whole, the author seems to have a sound understanding of the necessity, value, and difficulty of x-ray examination of mastoids.

HILLYER RUDISILL, JR., M.D.

The Roentgen Demonstration of Petrositis. Milton J. Geyman and Daniel M. Clark. Acta Radiol., 1932, XIII, Fasc. 2, 125-133.

Suppuration in the petrous portion of the temporal bone is frequently recognized by present-day otologists. It is characterized by suppurative otitis media, temporo-parietal pain, abducens paresis, and low-grade fever (Gradenigo's syndrome). Three groups of cases occur: (1) those arising during the course of an acute otitis media with little or no mastoid involvement; (2) those occurring during an acute mastoiditis, and (3) the type appearing as a post-operative sequel two or three weeks after mastoidectomy. In those cases falling under Groups I and II, prompt opening of the mastoid is indicated. In the third group Profant advocates conservative treatment with frequent paracentesis. Many of this type will recover without further surgery. When conservative measures fail, exenteration of the cells in the petrous tip often effects a cure.

Positions used in the study of the petrous portion of the temporal bone for eighth nerve tumors are not satisfactory when applied to the demonstration of petrositis. The most consistently useful positions are the vertico-mental and fronto-occipital, both of which are described and illustrated.

The changes occurring in petrositis are similar to those found in mastoiditis. An early involvement will show simply a haziness of cell outline and displacement of air. Later on, destructive changes are seen and finally healing, with sclerosis throughout the involved area. Ordinarily a roentgen diagnosis of petrositis is not justified in the absence of clinical symptoms. It is generally agreed that the condition occurs only in the pneumatized petrous and when sclerotic pyramids are demonstrated on both sides the likelihood of infection is remote.

D. M. CLARK, M.D.

EFFECT ON OFFSPRING

Comparative Histology of the Ovaries in its Relation to the Question of Injury of the Offspring Caused by Roentgen Rays. Rudolf Dyroff. Strahlentherapie, 1932, XLV, 711-733.

The author emphasizes the fact that nearly all experiments dealing with the production of mutations by irradiation were done by exposing the male gonads. He feels that the results so obtained cannot be accepted for the case in which the female gonads are exposed. The biologic difference between the two organs is too great for one to expect the same mutations in both cases. In the author's opinion there is no proof furnished as yet that temporary sterilization is injurious to the future offspring, provided it is carried out under the proper precautions.

ERNST A. POHLE, M.D., Ph.D.

The Genetic Foundations of Roentgen Mutations. Paula Hertwig. Strahlentherapie, 1932, XLV, 657-678.

Temporary Sterilization by Irradiation and Human Genetics. Hans Luxenburger. Strahlentherapie, 1932, XLV, 679-690.

The first article is a critical review of the experimental data accumulated so far as to the effect of roentgen rays and radium on mutations in plants and animals. The author comes to the conclusion that changes in the genes may occur following irradiation. It is probable that the majority of these changes are undesirable. No figures can be given as to the changes to be expected in human beings. However, the mere possibility of an injury to the offspring is sufficient to warn against that danger.

Luxenburger emphasizes the last conclusion and defends the resolution warning against temporary sterilization (see article by Wintz, *Strahlentherapie*, 1932, XLV, 653-656).

ERNST A. POHLE, M.D., Ph.D.

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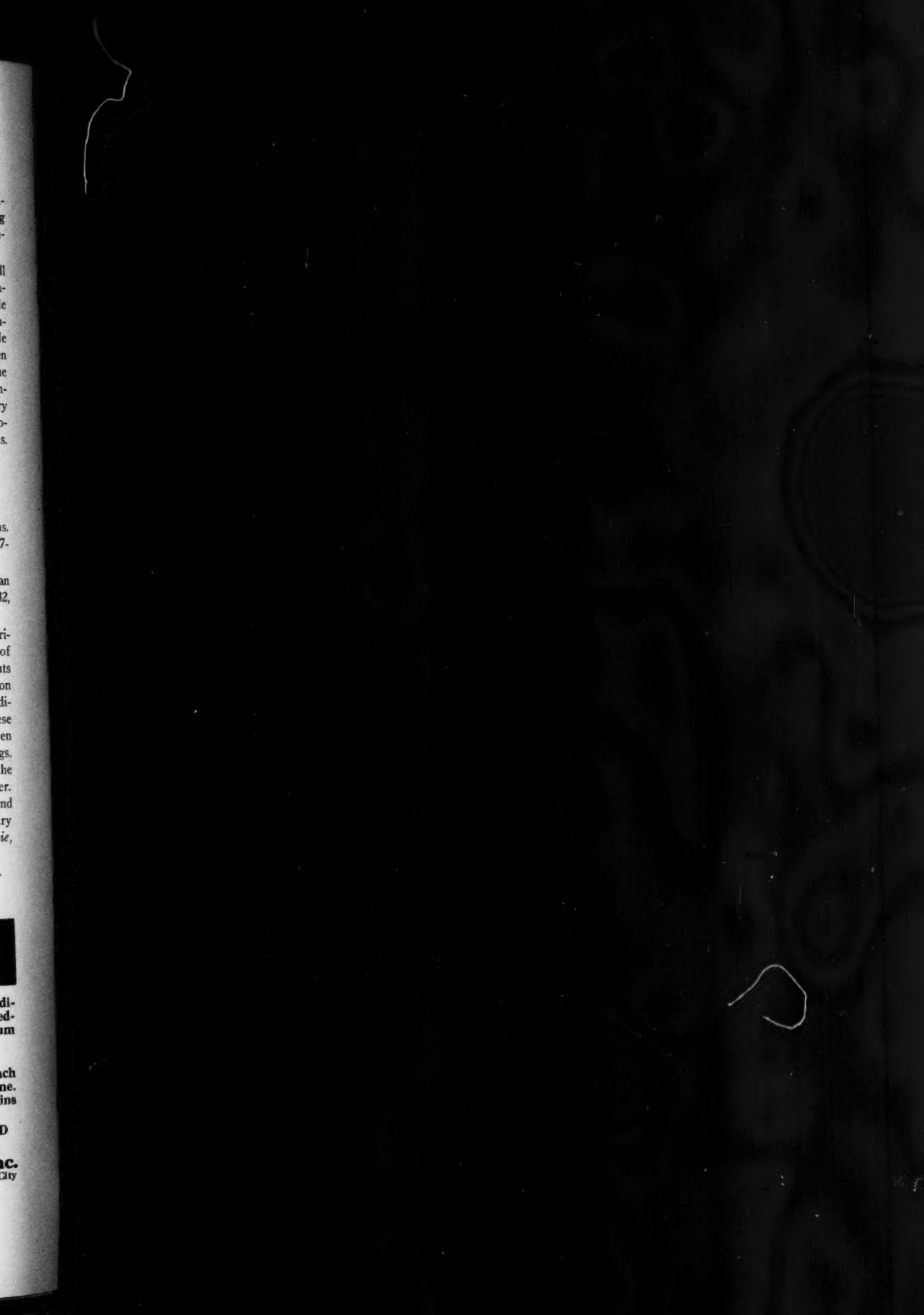
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